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U. S. Naval Observatory, Washington, DC 20392 December 7, 1989

Total Solar Eclipse of 11 July 1991

by

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and

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The U. S. Naval Observatory Eclipse Circulars

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Next Eclipse Circular: Annular Solar Eclipse of 15–16 January 1991
Available: mid-1990

A dark and eerie day

The coming solar eclipse offers scientists a rare opportunity to observe celestial drama up close

When the Earth's moon eclipses the sun, the darkening sky is just the start. Birds roost and flowers close their petals. Temperature drops, stirring gentle ecliptic winds. The last sliver of sunlight peeping from behind the moon is refracted by Earth's atmosphere to send "shadow bands" dancing across the ground like shadows rippling across the bottom of a swimming pool. The final specks of sunlight shine through the valleys on the moon's edge to make "Baily's beads," sparkling like a diamond ring. Then the land suddenly becomes as dark as a moonlit night, and the sun's corona forms a shimmering circle around the moon.

A total eclipse of the sun is always one of nature's most spectacular displays, but the one that will occur on July 11 promises to be extraordinary, both for tourists seeking entertainment and for scientists seeking a better understanding of the sun. While most eclipses can be observed only at sea or in remote regions, this celestial drama will be visible, weather permitting, to 40 million people along a narrow path that crosses the Big Island of Hawaii, the tip of Baja California and parts of Mexico and South America. The scientists among them will be favored by an unusual confluence of circumstances. Not only will it be the longest total eclipse since 1973—nearly seven minutes in some viewing spots—but by rare coincidence it will pass almost directly over Hawaii's 13,796-foot Mauna Kea, site of one of the most powerful concentrations of telescopes and astronomical instruments in the world. "It's a heaven-sent astronomical event," says NASA astronomer Steve Maran.

Ring around the sun? Scientists have several questions about the workings of the sun that they hope to illuminate with observations of this eclipse through Mauna Kea's seven specialized telescopes and other instruments. Giovanni Fazio of the Smithsonian Astrophysical Observatory will use sensitive infrared detectors and take advantage of the mountain's height to determine if the sun is circled by rings of dust, boulders and small asteroids. Astrophysicists have speculated that such rings might exist but have never before been able to verify them.

Scientists also hope to answer why the sun's shimmering corona, the incandescent gas that forms the solar atmosphere, is so much hotter than the sun's surface. Astronomers suspect that the sun's magnetic field somehow carries energy into the corona, thus heating its gases to more than 1 million degrees Kelvin even though the surface is only about 6,000 degrees K. One theory is that small loops of magnetically confined coronal gas called microflares, which take off from one spot on the surface and land at another, may be involved. Astronomers hope that shooting high-speed pictures of microflares as they change intensity during the eclipse will yield new clues about the puzzling solar dynamics.

This week's eclipse offers the first opportunity ever to use the latest astronomical technology in an ideal setting to search for such phenomena as solar rings. Mauna Kea's infrared detectors, which can make images of objects from the heat they radiate, are so new they have never before been used during a solar eclipse, and the mountain's elevation, above half the Earth's atmosphere, sharply reduces interference from dust and water vapor. "This could not have been done two years ago," says Kenneth Brecher, an astrophysicist at Boston University. "I'll be surprised if they see nothing."

The coming solar spectacle is drawing more than astronomers to Hawaii, Baja and the west coast of Mexico, sites where the weather almost assuredly will be clear. So many eclipse-chasing tourists are expected on the Big Island—at least 20,000 and possibly up to 60,000—that civil-defense authorities will go on full alert. Hotels are jammed, parks that don't usually allow campers will permit overnight stays, extra police will be on duty and tow trucks will be spotted along highways to unsnarl traffic jams. Mexico, too, is bracing for an invasion from the north. At the tip of Baja, where the eclipse will occur just as noontime temperatures hit 100 degrees, officials estimate the event will bring in $37 million, a year's worth of normal tourism.

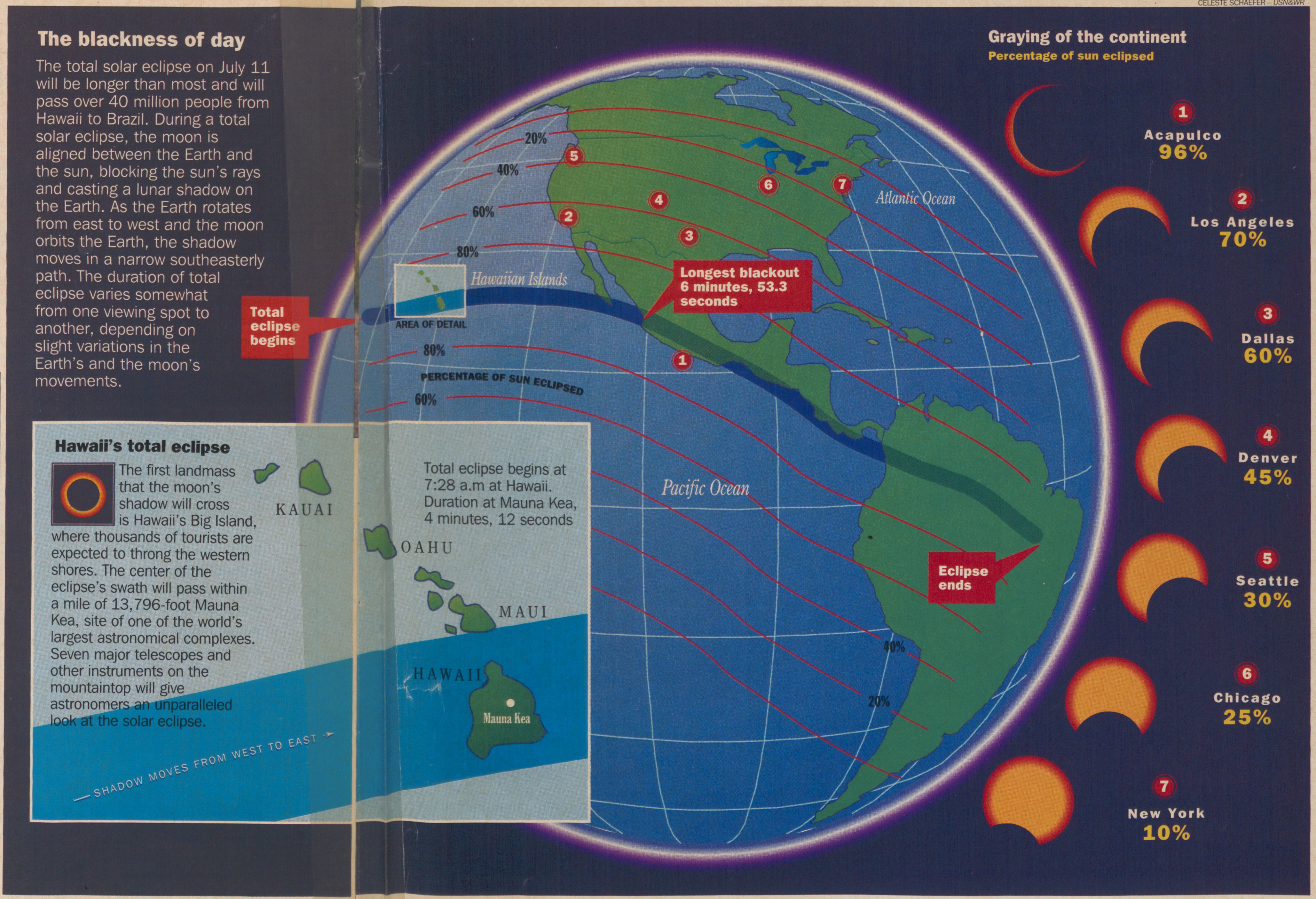
The curious are flocking for good reason. It will be eight years before another solar eclipse attracts as much attention as this. In August 1999, an eclipse will run from England across Europe to India. Those who wish to do their viewing closer to home will have to wait until 2017, when an umbra will cross the United States from Oregon to South Carolina. ■

BY WILLIAM J. COOK

JAY M. PASACHOFF—HOPKINS OBSERVATORY

Lunar halo. *The sun's corona in a 1984 solar eclipse*

CELESTE SCHAEFER—USN&WR



The blackness of day

The total solar eclipse on July 11 will be longer than most and will pass over 40 million people from Hawaii to Brazil. During a total solar eclipse, the moon is aligned between the Earth and the sun, blocking the sun's rays and casting a lunar shadow on the Earth. As the Earth rotates from east to west and the moon orbits the Earth, the shadow moves in a narrow southeasterly path. The duration of total eclipse varies somewhat from one viewing spot to another, depending on slight variations in the Earth's and the moon's movements.

Hawaii's total eclipse

The first landmass that the moon's shadow will cross is Hawaii's Big Island, where thousands of tourists are expected to throng the western shores. The center of the eclipse's swath will pass within a mile of 13,796-foot Mauna Kea, site of one of the world's largest astronomical complexes. Seven major telescopes and other instruments on the mountaintop will give astronomers an unparalleled look at the solar eclipse.

Total eclipse begins at 7:28 a.m at Hawaii. Duration at Mauna Kea, 4 minutes, 12 seconds

The wizard of education

A brash and brainy conservative is Bush's voice on school reform

President Bush labeled himself the "education president" throughout his campaign, and he has appointed as his secretary of education Lamar Alexander, once known as an "education governor." But the administration's true education philosopher—and the chief architect of Bush's master plan for fixing schools—holds no political office. He is a professor of education and public policy at Vanderbilt University named Chester Finn Jr.

Finn, 46, was Alexander's principal adviser on the key elements of the new "America 2000" plan: a national examination system, a network of experimental schools and public funding for private education. He wrote the early drafts of the blueprint, and he accompanied Alexander to the White House in March to sell it to the president. Yet Finn's role shouldn't be all that surprising. Brainy, brash—and to many the *bête noire* of American education—Finn has become the past decade's leading conservative commentator on what's wrong with the nation's schools and colleges.

Finn cut his conservative teeth in the Nixon White House and then, in the late 1970s, on the Senate staff of Daniel Patrick Moynihan, where he championed aid to private-school parents, a cornerstone of the Bush administration education agenda. But the Harvard-educated Finn says it was the lack of academic rigor at his children's prestigious Washington, D.C., private school in the late 1970s that convinced him that the nation's schools were failing and launched him on a decade-long "crusade" for educational excellence.

Offstage. During the mid-1980s, Finn was a top aide to Secretary of Education William Bennett, supplying much of the rhetorical ammunition for Bennett's blistering critiques of the nation's schools and colleges. His relationship with Lamar Alexander dates to the early 1980s, when, as governor of Tennessee, Alexander tapped Finn, then at Vanderbilt in Nashville, to draft what was Alexander's first major foray into education policy making—a sweeping reform package that centered on the then radical idea of rewarding teachers for classroom performance.

Finn has above all been a vocal and relentless critic of the educational liberalism of the 1960s and 1970s, using a small Washington, D.C.-based think tank as a bully pulpit. In eight authored or coauthored books and more than 200 newspaper and magazine articles, Finn has attacked the nation's educators for their "preoccupation" with promoting equal educational opportunity at the expense of high standards and their "abhorrence" of testing and other measures of achievement. He has savaged what he sees as an undue emphasis on the emotional well-being of students at the expense of their intellectual development. He has also advocated teaching a core of history, literature, math and science courses to all students, and has proposed that students be denied diplomas and even drivers' licenses until they master such material. He has relentlessly attacked the argument that the proposal is "elitist."

CHARLIE ARCHAMBAULT—*USN&WR*

Everyone should have standards. *Chester Finn denies critics' charges of elitism.*

Finn pulls no punches in his highly quotable critiques. (The "educational establishment," he wrote recently, "has deflected the Roto-Rooters of reform from clearing the blockages and backups in what was already an ill-designed plumbing system.") To his critics' dismay, Finn rarely concedes that disadvantaged students need help to meet high standards or that teachers labor under difficult conditions. His unyielding insistence on "individual responsibility" and "institutional accountability" has led opponents to label him an educational "Darwinist."

Finn is unrepentant about such charges, insisting that "the race is to the swift" in education as in life. He backs public funding of private schools, he says, because competition with private schools would improve public schools. Besides, he says, "it's un-American to force students to go to schools they don't want to attend."

The vituperativeness of Finn's attacks has turned many educators against him. "His ideas are a lot more palatable in Lamar's velvet gloves," acknowledges a fellow Alexander adviser. Yet, friends and foes alike say Finn has provoked a much needed re-evaluation of the nation's educational priorities in recent years. In the words of Nelson Andrews, chairman of the Tennessee State Board of Education: "He's a raspberry seed in your wisdom tooth; he makes you think." ■

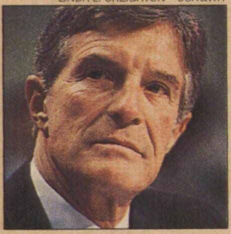
BY THOMAS TOCH

TOMORROW

PLAYING CENSUS POLITICS

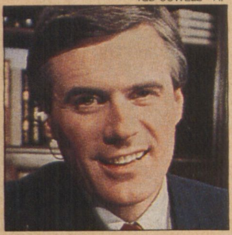
BY MICHAEL BARONE

LINDA L. CREIGHTON—*USN&WR*



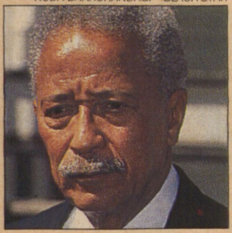
■ Commerce Secretary Robert Mosbacher is expected to refuse to adjust the 1990 census results to reflect undercounts—even though an adjustment might benefit his party.

TED COWELL—AP



■ Ohio Democrat Tom Sawyer would like to see the 1990 census head count changed to reflect the undercount—even though that would increase Ohio's population by less than 1 percent.

HODA BAKHSHANDAGI—BLACK STAR



■ New York Mayor David Dinkins has mounted a legal challenge to the 1990 head count. But the new congressional seats would go to Los Angeles and Phoenix, not New York.

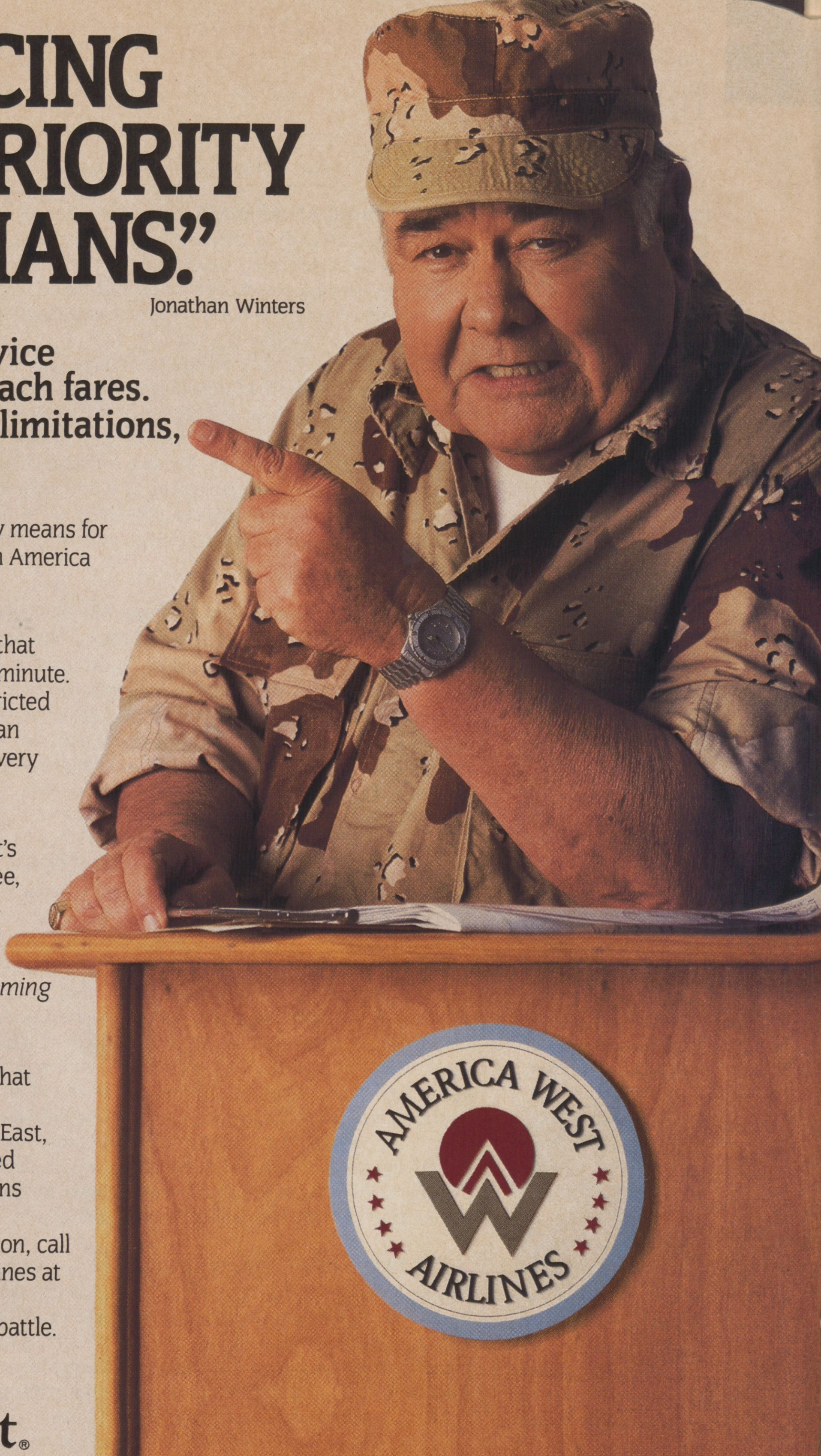
■ ADJUDICATING ADJUSTMENTS. Should the Census Bureau head count for 1990 be revised (or, to use the technical word, *adjusted*) for the first time in 200 years? Commerce Secretary Robert Mosbacher must decide by next Monday. His decision will be hailed—and criticized—for its immediate political impact, though that's likely to be small. What's more important is that adjusting the count could open the door to the politicization of the census.

In 1787, when the framers of the Constitution settled on an "actual enumeration" of population every 10 years to apportion House seats among the states, no other country in the world had ever had a regularly scheduled census or tied political representation directly to population. For most of the 200 years since, politicians have let their political fates be determined by a count they couldn't directly influence. The one exception came after the 1920 census announced that most Americans lived in urban places of 2,500 or more, and a rural-based Congress refused to reapportion seats to give more clout to fast-growing industrial cities. In response, the nation's most statistic-minded president, Herbert Hoover, pushed through a bill providing automatic reapportionment after the census.

■ UNEXPECTED WINNERS AND LOSERS. The controversy over the 1990 census centers on a legal challenge brought by New York City Mayors Edward Koch and David Dinkins, who feared that undercounts in tightly packed Gotham would result in less representation and less federal aid. Many industrial-city mayors and Rust Belt Democrats, noting that studies showed the largest undercounts were among young black males, joined in. The judge in New York's lawsuit ordered the Census Bureau to conduct a post-head-count survey to gauge the undercount. Using one of several possible models, the bureau estimated that census counters missed nearly 10 million Americans and double-counted more than 4 million, for a net undercount of about 5.3 million—more than 2 percent of the total population.

For some, that settles the issue. "The original census numbers are on their face demonstrably wrong," says Ohio Democrat Tom Sawyer, chairman of the House census subcommittee. "The adjusted numbers would be closer to the truth." But even Sawyer admits that adjusted numbers would not be more accurate for every municipality or city block. Nor would they have the expected political effects. The biggest undercounts do seem to be among the underclass and illegal immigrants, groups concentrated in big cities. But geographically, the biggest miscounts are in the West and South. The four states with the highest undercounts are those along the Mexican border; the municipality with the biggest undercount is Inglewood, Calif., a suburb near the Los Angeles airport. Democrats have been more vocal in demanding a census adjustment. But the adjusted figures would give one House seat each to California and Arizona, probably to fast-growing Republican areas, and take one each from Pennsylvania and Wisconsin, where the victims might well be Democrats. Not surprisingly, among those opposing an adjustment are Herb Kohl, chairman of the Senate census subcommittee, whose doubts about adjustments turned to opposition the day his home state of Wisconsin appeared on the list of losers, and Tom Ridge of Pennsylvania, ranking minority member of Sawyer's panel, who has opposed readjustment all along.

■ THE PERILS OF POWER. Those politically divergent views illustrate the perils of politicizing the census. The problem is that while statisticians can come up with an estimate experts can defend intellectually as more accurate than the head count, at least for the nation as a whole, they can't come up with an estimate they can defend as definitely more accurate than all other estimates. Sawyer believes a "statistical control mechanism would work vastly better" than the Census Bureau's head count, which he points out got less accurate between 1980 and 1990. But in practice, politicians are likely to pick the adjustment that works to the political benefit of their particular state or party. Adjusting the numbers this time would tend to give politicians in Congress that power. And that helps explain what at first seems odd: why Sawyer, whose party stands to lose by an adjustment this year, tends to favor it, while Mosbacher, whose party might gain this time, is widely assumed to be leaning against.



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A no-win situation. *The Serbian-dominated Yugoslav Army is critical to the future of a disintegrating nation.*

The fire this time

Why Yugoslavia is a candidate for creative destruction

All the king's horses and all the king's men could not put Humpty Dumpty together again, and neither Army tanks nor American and European reproaches can reconstruct Yugoslavia. The artificial federation that spans the quarrelsome Balkans fell apart as soon as communism went under. The Western powers, reflexively opposed to any border changes in volatile Central Europe, narrowly missed allying themselves with a Yugoslav Army whose die-hard communist generals answer mostly to themselves. The issue, however, is not how to hold Yugoslavia together but how to promote its evolution into something its feuding peoples can live with.

The easiest thing to understand about Yugoslavia is why it is breaking up. The region has long been held together by dictators. A Serbian monarchy first did the trick, grimly, between the two world wars. After 1945, the ethnic powder keg was fused into a federation of six republics by Tito, the communist guerrilla chief whose struggle against Hitler in the Balkans concentrated power in his hands. Yugoslavia's fragile postwar unity was aided by the hovering threat of the Soviet Union, whose clutches Tito coolly avoided. With both Tito and communism dead, rival republics with freely elected leaders are pursuing their own agendas.

At the top of these is nationalism. Although little Slovenia, an Alpine republic of 2 million people, has taken the initial brunt of Yugoslavia's war of dissolution, the conflict is driven by the rivalry between the two largest republics, Serbia and Croatia. Between them runs the old boundary marking the Ottoman and the Habsburg empires, gone but not forgotten. Mutual suspicion between Serbs and Croats remains intense; it encapsulates the strains among Balkan Slavs.

Bad neighbors. Like the Slovenes, the Croats are Habsburg Catholics whose attachments are to the western Europe that lies just over the Alps and across the Adriatic. Serbia, with 40 percent of Yugoslavia's 23 million people, was an independent kingdom until 1918; Orthodox by religion, it looks eastward. The fact that pro-Hitler fascists took over an expanded Croatia in World War II and massacred Serbs only deepens the Serbs' mistrust. During that war, many more Yugoslavs were killed by fellow Yugoslavs than by foreign soldiers.

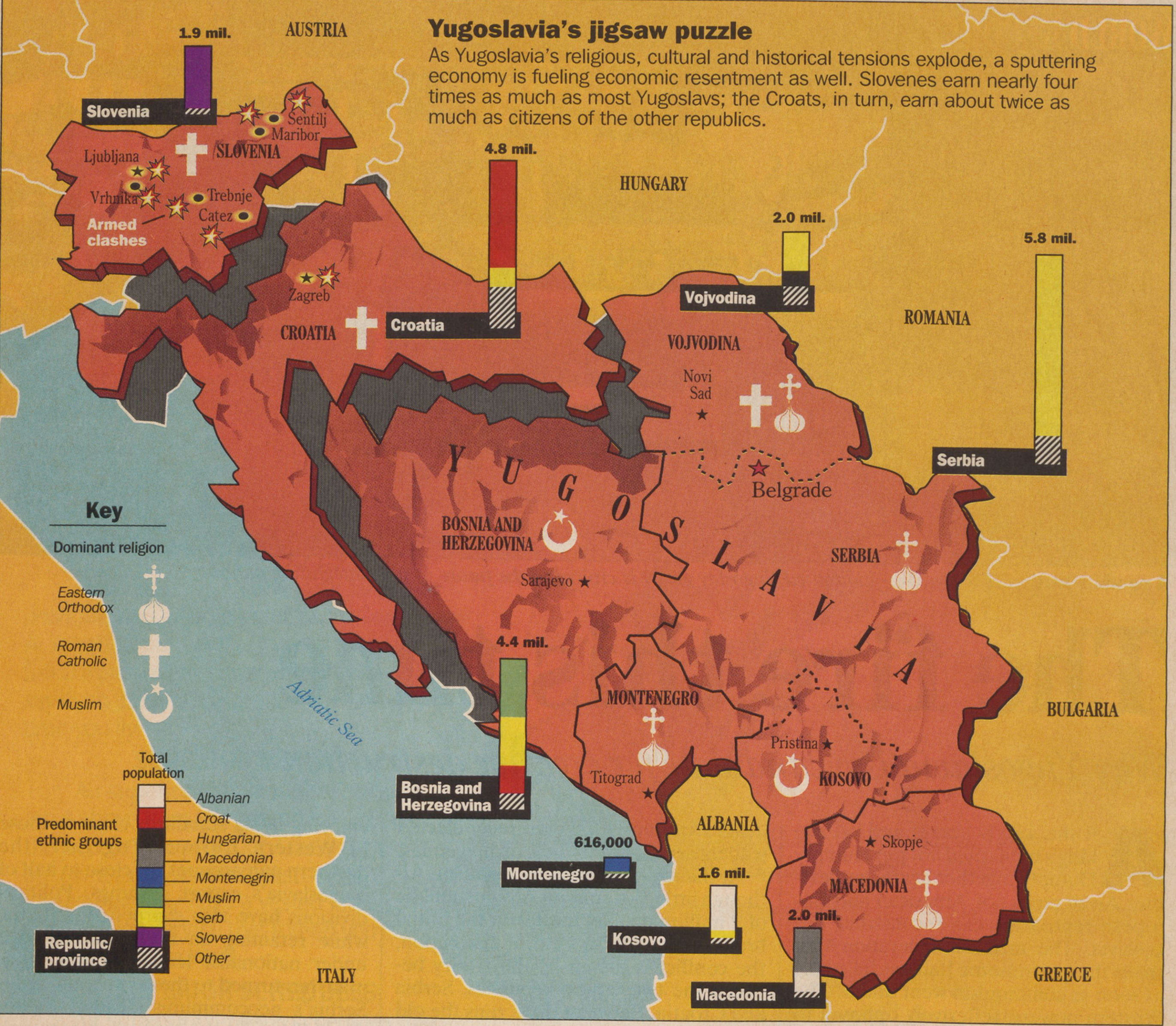
Economically, Yugoslavia has its own north-south split. Croats are much better off than Serbs. Slovenia is richer still, enjoying living standards close to those in Western Europe. Together, the northern pair account for close to half of Yugoslavia's export earnings. Political divisions have also sharpened. Croatia, while retaining an authoritarian edge under nationalist leader Franjo Tudjman, has turned to the democratic right. Serbia's neocommunist leader, Slobodan Milosevic, has embraced nationalism to bolster his eroding popularity.

As federal authority has evaporated, the feuding republics have come up with conflicting solutions. It is over these that the war is being fought. By declaring themselves independent on June 25, Croatia and Slovenia escalated their campaigns for a loose association of sovereign states in place of the current federation. They are not precise about how loose the grouping might be, but it would have to be loose indeed to permit the pair to join the European Community, which is their ultimate goal.

This big change might be acceptable to two other republics that mostly mind their own business, Macedonia and Bosnia and Herzegovina. It is not acceptable to Serbs for two reasons: It would drastically dilute the power Serbia exercises over its neighbors, and it

DAVID BRAUCHLI—REUTER

DAVID S. MERRILL—*USN&WR*


AUSTRIA
HUNGARY
ROMANIA
BULGARIA
GREECE
ALBANIA
ITALY
Adriatic Sea
YUGOSLAVIA
SLOVENIA
CROATIA
VOJVODINA
SERBIA
BOSNIA AND HERZEGOVINA
MONTENEGRO
KOSOVO
MACEDONIA
Ljubljana
Vrhnika
Trebnje
Catez
Sentilj
Maribor
Zagreb
Novi Sad
Belgrade
Sarajevo
Titograd
Pristina
Skopje
Armed clashes
1.9 mil.
Slovenia
4.8 mil.
Croatia
2.0 mil.
Vojvodina
5.8 mil.
Serbia
4.4 mil.
Bosnia and Herzegovina
616,000
Montenegro
1.6 mil.
Kosovo
2.0 mil.
Macedonia
Key
Dominant religion
Eastern Orthodox
Roman Catholic
Muslim
Total population
Predominant ethnic groups
Albanian
Croat
Hungarian
Macedonian
Montenegrin
Muslim
Serb
Slovene
Other
Republic/ province

Yugoslavia's jigsaw puzzle

As Yugoslavia's religious, cultural and historical tensions explode, a sputtering economy is fueling economic resentment as well. Slovenes earn nearly four times as much as most Yugoslavs; the Croats, in turn, earn about twice as much as citizens of the other republics.

would strand some 30 percent of ethnic Serbs who live outside Serbia, notably in Croatia. Serbia's solution is the status quo ante—that is, maintenance of a tight federation in which Slovenia and Croatia retract their independence. Bound to Serbia are the mountain republic of Montenegro and the provinces of Vojvodina and Kosovo, though the latter, inhabited by ethnic Albanians, is loyal only because Serbs force it to be.

Serbian leaders hope the Army will be their enforcer. Led by officers who are mostly communists and 70 percent Serbs, the Army that is now trying to slam shut the doors of Yugoslavia's emptying stable is ideologically convinced of the need to keep the federation intact. Financially convinced, also. Without funds from Croatia and Slovenia, the Yugoslav Army would break down. But the Army now finds itself claiming to fight for a state that no longer exists. In fact, it is fighting for itself and for some kind of communist continuity that is now alien to Yugoslavia, where most republics—except Serbia and Montenegro—have installed anticommunist governments.

Slovenia first. Just how closely the Army and Serbia are allied is unclear. In Belgrade last week, Serbian students held a vigil at the Serbian Assembly building, proclaiming, "We have no quarrel with Slovenia—let them go." But the Army, having broken its civilian reins, tried to crack down on the Slovenes first, perhaps because the generals knew a move against Croatia could unleash uncontrollable violence. Slovenia made itself the logical target: It pushed further than Croatia toward independence by taking command of border posts.

But a multiethnic conscript Army is a questionable tool for settling ethnic quarrels. What's more, the Yugoslav Army is the last institution still largely intact from Tito's day, and many of its top officers won their posts on the basis of political loyalty, not professional competence. Anxious to preserve the fiction that the Army was operating in friendly territory, commanders sent tank columns across the Slovenian border without advance reconnaissance, without proper infantry or air support and without securing the necessary supply lines. "They were put in a no-win situation, not able to strike with full force against Slovenia yet perceived as no better than the Russians in Prague in 1968 or Budapest in 1956," says one Western diplomat in Belgrade.

Croatia chose to watch how Slovenia

WORLDGRAM

POWER PLAYS IN LEBANON INCREASE THE PRESSURE ON ISRAEL

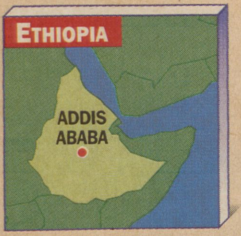
LEBANON
BEIRUT

■ About 350,000 Palestinians live in Lebanon, a majority in two large refugee camps—Ein Helweh and Mieh Mieh—located near the port city of Sidon. Some 6,000 Palestinian fighters are based in the camps. Only 8 miles to the east of Sidon lies the edge of Israel's "security zone," carved out to protect villages in Galilee from terrorist bands and Palestinian rocket attacks.

■ **LEBANON TRIES TO RECOVER ITS SOVEREIGNTY.** By deploying its Army south of Sidon for the first time in 16 years, forcing Palestinian fighters back into their refugee camps and emerging from the exercise more or less unscathed, President Elias Hrawi's Syrian-backed "government of national reconciliation" in Beirut has taken major steps toward ending Lebanon's 16-year-old civil war. But the chances of Israel's responding by quickly withdrawing from the "security zone" it controls in southern Lebanon are slim.

Hrawi's motives for the risky move are clear: He was eager to regain sovereignty over Lebanese territory, to show that the reformed Lebanese Army can hold together under pressure and to convince Israel that with the Palestinian threat in southern Lebanon neutralized, it is now time to get out of the country. He was sending the United States a signal, too. If Hrawi (read Syria) can be believed, the Bush administration may begin to press Jerusalem to withdraw from southern Lebanon once the Lebanese Army is fully deployed there. That could take months; the Palestinians have until mid-September to lay down their arms. In any case, there are fears that the disarmament will prove partial and cosmetic, allowing Yassir Arafat's Palestine Liberation Organization as well as anti-Arafat Palestinian terror groups to resume using Lebanon as a base for launching attacks and artillery fire into northern Israel at some later date. It is, moreover, in a nervous Israel's strategic interest to keep the new-look Lebanese Army and its Syrian guarantors as far from Israel's borders as possible.

Syria's role in this turn of events is murky but central. President Hafez Assad is eager to head off any possibility of a separate Palestinian-Israeli peace deal that might leave the strategic Golan Heights in Israeli hands, and he is determined to assert Syrian control over developments in Lebanon. Weakened by the gulf war and with the West Bank *intifada* sputtering, the PLO has few options and little leverage over the Hrawi government. And having publicly vowed to oppose the Lebanese Army deployment, Arafat again has been humiliated. Yet the PLO clings to its dream of a "state within a state" in Lebanon and will do its utmost to hang on to its arms. At present, it suits Assad to weaken the PLO, keep tension on the Golan Heights to a minimum and use his warmer relationship with Washington to pressure Jerusalem diplomatically. Longer term, however, the Syrian leader is reluctant to abandon the option of allowing Palestinian groups to resume their attacks on Israel.



■ Two dozen political factions are jostling for power in Ethiopia. Most are regionally or ethnically based and none of them commands any nationwide support. In Eritrea the main rebel group refuses to join in a new transitional government.

■ **ETHIOPIA WOBBLES BETWEEN BREAKUP AND DEMOCRACY.** An early-July meeting in Addis Ababa attended by all the rebel groups that overthrew the Mengistu regime in May may have cleared the way for multiparty elections in Ethiopia in 1993. A society based on regional autonomy, a market economy and respect for human rights could follow.

But before an age of reason dawns in one of the world's poorest states, huge obstacles have to be overcome. First and foremost, a lasting compromise must be hammered out over Eritrea, the Red Sea province where a secessionist revolt has dragged on for 30 years. At the Addis conference, some progress was made: A referendum on independence, supervised by the United Nations, is to be held in two years in return for allowing any Ethiopian government access to the port of Assab.

Still, many in the main rebel group, the Tigréan-led Ethiopian People's Revolutionary Democratic Front, are opposed to Ethiopia's breakup and will resist any decentralization. Second, ethnic differences run deep in Ethiopia and are sure to destabilize the interim government that is to rule until 1993, hampering agreement on a new constitution—a key precondition for free elections. Third, given the current weakness of central authority in Ethiopia and the refusal of most armed groups to disband, the potential for further breakaway rebellions is high, particularly in the eastern Ogaden region and among the southern Oromo people. So far, the EPRDF's tough-minded leader, Meless Zenawi, has restrained his Marxist, authoritarian impulses in the interests of national unity. He has, however, vowed to fight against anyone other than the Eritreans wanting to secede. As a two-year transition begins in Ethiopia, this could be the greatest danger of all to a democratic future.

BY RICHARD Z. CHESNOFF AND DAVID MAKOVSKY IN JERUSALEM AND AIDAN HARTLEY IN ADDIS ABABA

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GENERAL INFORMATION

A total eclipse of the Sun will occur on Thursday, 11 July 1991. It will be preceded by an associated penumbral eclipse of the Moon on 27 June, and will be followed by another penumbral lunar eclipse on 26 July. Roughly half of the central path of this eclipse will pass over land, including many major population centers. The maximum duration of totality (approximately 6m 58s) will be the longest of all remaining total solar eclipses in this century. This eclipse belongs to saros series number 136. The last preceding eclipse in this series was the total solar eclipse of 30 June 1973; the next eclipse in the series will be the total solar eclipse of 22 July 2009.

Prior to this eclipse, a total solar eclipse will occur on 22 July 1990 over Finland, northern Siberia, and the Aleutian Islands. After that, an annular solar eclipse will occur on 15-16 January 1991 over Australia, New Zealand, and the South Pacific Ocean. The next total solar eclipse following the 11 July 1991 event will occur on 30 June 1992 over the South Atlantic Ocean and a very small part of the east coast of South America.

PATH AND VISIBILITY

Inexperienced observers are cautioned to observe only by use of projected images, and not to use any method which would cause them to look directly at the Sun.

At approximately 17h 23m UT on 11 July 1991, the center of the umbra of the Moon's shadow will touch the Earth at sunrise at a point in the North Pacific Ocean, southwest of Hawaii. At this time, the path will be approximately 206 km wide and the duration of totality on the center line will be approximately 3m 14s. The center line will reach the Hawaiian Islands about 6 minutes later. The central path will completely encompass the "big island" of Hawaii with its northern limit grazing the southern coast of Maui. The southern limit will pass over the Pacific Ocean, south of Hawaii. The center line will pass very close to the summit of Mauna Kea. By 17h 30m UT, the path will have grown in width to approximately 226 km and totality will last approximately 4m 11s on the center line. The eclipse will be an early morning event in Hawaii, with the Sun located at an altitude of about 21° in the northeastern sky.

The central path will continue over the North Pacific Ocean, making its next landfall at the southern tip of Baja California. The center line will reach the west coast of the peninsula at approximately 18h 50m UT. By this time, the Sun will be much higher in the sky, located at an altitude of about 81°. The central path will be approximately 260 km wide and totality will last approximately 6m 56s on the center line– about 2 seconds short of the maximum. As in Hawaii, the southern limit will be inaccessible from land. The population centers of La Paz and Villa Constitucion are among the locations on the peninsula that will be within the central path. The maximum duration of totality (approximately 6m 58s) will occur about 10 minutes later over the Gulf of California.

The central path will continue to the mainland of Mexico, with the center line reaching the west coast near Tuxpan at approximately 19h 05m UT. The Sun will be very close to the zenith at this time. Many major Mexican cities and towns will be within the central path; these include Mazatlan, Aguascalientes, Guadalajara, Leon, Morelia, Toluca, Mexico City, Cuernavaca, and Puebla. The center line will reach the border with Guatemala at approximately 19h 46m UT. By this time the path will be approximately 257 km wide, with the duration of totality approximately 6m 23s on the center line. The Sun will be located at an altitude of about 67° above the southwestern horizon as the center line leaves Mexico.

Many major Central American cities also will lie within the central path of the eclipse. These include Guatemala City (Guatemala), San Salvador (El Salvador), Managua (Nicaragua), San Jose (Costa Rica), and David (Panama). The Panama Canal Zone will lie to the north of the central path, and hence, will not experience total eclipse. The southern limit of the central path will be inaccessible from land throughout Central America, as it will track just offshore over the Pacific Ocean. The center line leaves Central America at approximately 20h 16m UT. At this time, the path width will have shrunk to about 249 km, the duration of totality on the center line will be approximately 5m 26s, and the Sun will be located at an altitude of approximately 47° above the northwestern horizon.

The center line will reach the Colombian coast of South America at approximately 20h 23m UT, crossing the Andes mountains about three minutes later. The Colombian cities of Buenaventura, Cali, and Neiva will be located within the central path. The center line will reach the border with Brazil at approximately 20h 36m UT. At this time, the path width will be approximately 235 km, the duration of totality on the center line will be approximately 4m 30s, and the eclipsed Sun will be located about 29° above the northwestern horizon. Access to the central path in Brazil will likely prove difficult. There are no major Brazilian cities within the track. The center line will cross the Amazon River at approximately 20h 39m UT and continue through Brazil until it finally leaves the Earth at sunset at approximately 20h 49m UT, north of Brasilia.

Partial phases of the eclipse, of magnitude decreasing with the distance from the path of the total phase, will be visible over most of the United States (except Alaska and the extreme northeast), south central and southwestern Canada, the Caribbean region, Mexico, Central America, and northern and central South America.

SKY AT MAXIMUM TOTALITY

Diagrams of the sky as it will appear at maximum eclipse from three locations along the path over land are given elsewhere in this *Circular*. Centered on the zenith for each of the locations, the diagrams show planets and stars brighter than magnitude 2.0. At the time of the eclipse, the Sun and Moon will be in the constellation Gemini. As seen from Hawaii, maximum eclipse will occur in early morning; thus, the Sun and Moon will be low in the northeastern sky. No bright planets will be above the horizon during totality. Castor and Pollux will be the bright pair of stars just to the north of the eclipsed Sun. Bright Sirius will be present low in the southeastern sky. As seen from the Baja California, maximum eclipse will occur with the Sun and Moon very near the zenith. The bright planets Mercury (–0.1), Venus (–4.5; six days before greatest brilliancy), and Jupiter (–1.8) will all be present east of the eclipsed Sun. Fainter Mars (+1.8) will also lie to the east. Mars, Venus, and the star Regulus will form a compact grouping. Venus will be only 1° south of Regulus; five days later, Mars will pass 0°.7 north of the star. Castor and Pollux will be the bright pair now to the northeast of the Sun and Moon; Sirius will be present almost directly due south. As seen from Brazil, near the end of the track, the eclipsed Sun will appear low in the northwestern sky. Again, Mercury, Venus, Mars, and Jupiter will be above the horizon, but now located to the southeast of the Sun and Moon. Sirius will be present low in the southwestern sky, while Arcturus and Spica will be bright objects in the eastern sky.

CHANGE IN CONTENTS

Detailed maps are provided for the entire central path over land. However, the maps of Hawaii and Baja California are given at a different scale than the other maps (see *Detailed Path Maps* below). Also, at the beginning and end of the central path, the dashed time lines are given at 30-second intervals instead of the usual one-minute intervals. A small arrow on each map, located on the central line at a time mark, indicates the azimuth of the Sun at that point. The altitude of the Sun at the point is given in the accompanying label. Continuing a change made in the last eclipse *Circular*, the table giving the central path as a function of longitude at flying altitudes is replaced by a table providing the path of the central line at flying altitudes as a function of time. No refraction corrections have been applied in the table of local circumstances for geographic locations. All locations are assumed to be on the surface of the reference ellipsoid, except for the observatories, whose heights were included in the calculations (see *Local Circumstances* below). Three sky diagrams (for Hawaii, Mexico, and Brazil) and limb correction diagrams (for Hawaii, Mexico, and Colombia) are provided.

PARAMETERS AND CORRECTIONS

The predictions in this *Circular* are derived from the solar and lunar data contained in the DE200/LE200 ephemeris developed jointly by the Jet Propulsion Laboratory and the U. S. Naval Observatory for use in the *Astronomical Almanac* for 1984 and after. In order to best take into account the rough limb of the Moon, the value of $k = 0.2725076$ for the ratio of the radius of the lunar profile to the Earth's radius is used throughout the calculations. The International Astronomical Union (IAU) adopted the new value for k in August 1982. Along with that value, corrections have been applied to both lunar latitude and longitude to help account for the difference between the center of figure and the center of motion (see *Elements of the Eclipse* elsewhere in this *Circular*). It is expected that the observer will then make the final limb corrections, as described elsewhere in this *Circular*. As usual, all time arguments are in Universal Time (UT), using the best value of ΔT [the difference between Terrestrial Dynamical Time (TDT) and UT] available at the time of preparation (see *Elements of the Eclipse*). The convention of longitude positive east is used throughout this *Circular*.

DETAILED PATH MAPS

The detailed maps provided in this *Circular* are presented on portions of the Defense Mapping Agency's Operational Navigation Charts (ONC), scale 1:1,000,000, Lambert Conformal Conic Projection. The maps of Hawaii and Baja California given in this *Circular* have been reduced to 66% of original size, enlarging the scale from 15.78 miles/inch to 23.91 miles/inch. All of the remaining maps have been reduced to 50% of original size, enlarging the scale from 15.78 miles/inch to 31.56 miles/inch. As previously noted, a small arrow on each map, located on the central line at a time mark, indicates the azimuth of the Sun at that point. The altitude of the Sun at the point is given in the accompanying label. For an explanation of the maps, see *Estimating Second and Third Contacts* below.

LOCAL CIRCUMSTANCES

DEFINITIONS. *First* and *fourth contacts* are, respectively, the beginning and the end of the partial phase. *Second* and *third contacts* are, respectively, the beginning and end of the total phase, if it occurs at the given location. *Duration* is the time interval between second and third contacts. Dot leaders indicate that a phenomenon occurs below the horizon for a given location.

The *position angle* of a point of contact on the solar limb is measured eastward (counterclockwise) around the solar limb. *P* is the position angle measured from the north point on the limb; *V* is the position angle measured from the vertex point. The *north point* lies on the great circle arc drawn from the north celestial pole to the center of the solar disk; the *vertex point* lies on the great circle arc drawn from the zenith to the center of the solar disk. If the angle is listed as negative, add 360°.

The *azimuth* of the Sun is measured along the horizon clockwise from the north point eastward to the foot of the great circle arc drawn from the zenith through the center of the solar disk down to the horizon. If it is listed as negative, either add 360° or measure westward from north.

The *magnitude* of the eclipse is the fraction of the apparent diameter of the solar disk covered by the Moon at the time of greatest phase, expressed in units of the solar diameter.

Degree of obscuration, computed especially for this *Circular*, is the fraction (per cent) of the area of the apparent solar disk obscured by the Moon at maximum eclipse.

TABLES. In addition to the table of local circumstances on the center line, a table of accurate local circumstances for a list of selected geographic locations is provided. The locations were chosen for their position near the central path, general geographic distribution, and size of population. Coordinates were taken from *The Times Atlas* or read from the detailed maps in this *Circular*. All coordinates are approximate and assumed to be on the surface of the reference ellipsoid, except for the tabulated observatories, whose coordinates (including height) were obtained from the *Astronomical Almanac's* observatory list. The printed circumstances correspond to the printed coordinates, in case there should be an error in identification or coordinates. It is often difficult in preparing maps and local circumstances to ascertain the correct name and spelling for a given location.

Therefore, the information presented here is for location purposes only; it is not authoritative, and does not imply recognition of the status of any area by the United States Government. The tabulated local circumstances are not corrected for refraction. For the user who wishes to calculate local circumstances, the elements of conjunction, general circumstances, and Besselian Elements for UT arguments are provided. The Besselian Elements are given as usual in tabular form, and also in polynomial form. Precepts for the calculations of local circumstances can be found in the Explanation of the *American Ephemeris and Nautical Almanac* for 1980 or earlier years.

ESTIMATING FIRST AND FOURTH CONTACTS. Beginning and end of the partial phase, or first and last contacts, can be estimated using the one-page overall map reproduced in this *Circular* from the *Astronomical Almanac*. The dashed lines show the surface outline of the Moon's penumbra at a time interval of 30 minutes. The short dashes show the leading edge, the long dashes show the trailing edge. First contact occurs when the leading edge passes over the location in question, last contact occurs when the trailing edge passes. Duration is the time difference between contacts. The time halfway between is the middle of the eclipse. This is near the time of maximum eclipse, but not necessarily identical. At a given location, one need only estimate the intermediate position of the penumbra's edge between the starting and ending lines on either side and thus the time of the contact. For observers within the elongated "teardrop" curves to the extreme east and west, part of the eclipse occurs below the horizon.

ESTIMATING SECOND AND THIRD CONTACTS. Low precision times of second and third contacts in the central path can also be estimated. The central path over land is shown on a series of detailed maps in this *Circular*. Elsewhere in the *Circular* is a table of Local Circumstances for Points on the Central Line. On the maps, the heavy solid lines mark the northern and southern limits of the predicted path. Each dashed line represents the projection of the diameter of the umbra, joining the northern and southern limits and central point for the indicated instant, at which all points on the dashed line experience maximum eclipse. Use the maps and table as follows: Find on the maps the location in the path for which you want local circumstances. From the one-minute cross lines on either side, estimate or measure the time t_0 when the projected axis line of the umbra will pass over the point. Turn to the table of Local Circumstances for Points on the Central Line. Find where the time t_0 fits into the first column on each page. Using the appropriate fraction of the time interval, read across both pages and interpolate the times of second and third contacts, the duration (D), and the width of the path (a). Make a note of the angles P and V for each contact (for use as described in the next section), and also the altitude (a) and the azimuth (A) of the Sun at maximum eclipse. Turn back to the map. If you mark the cross lines for the second and third contact times, you can see the breadth of the projected shadow. Now draw a line through the observing point perpendicular to the path. Estimate or measure how far the point is from the center of the path and call this quantity b (a and b must be in the same units). Next compute the approximate duration (T) for the selected location by:

$$T = D\sqrt{1 - (2\mathrm{b}/\mathrm{a})^2}\ .$$

Then, the time of second contact is approximately $t_0 - T/2$, third contact $t_0 + T/2$.

ESTIMATING POSITION ANGLES. The lunar limb profile for this eclipse is provided elsewhere in this *Circular*. For locations in the central path, the predicted times and position angles of contacts are based on the Moon's mean limb (the smooth circle). Correction for limb irregularities is discussed later. In working with this construction, remember that the position angles are given for the solar disk, which is observable, but corrections are based on features on the lunar disk, shown in the diagram. The two nearly coincide between second and third contacts, so it is adequate to plot angles pertaining to the Sun on the lunar diagram. However, this is not the case for first and fourth contacts. You may find it convenient to use a transparent overlay with a circle of radius three inches.

For each second or third contact to be sketched for a location given in a table, take from the table the time of contact (t_c), the angles P and V, and the altitude (a) and the azimuth (A) of the Sun at maximum eclipse, as described above. Convert the time of contact to hours and decimals. The topocentric position angle of the lunar axis (C) is a function of time, the position of the Moon and the Sun, and the location of the observer. For this eclipse, compute C from the following equation:

$$C = 1^\circ.53 + 0^\circ.258\,t_c - 0^\circ.41 \cos a \sin (P - V).$$

On the diagram, N marks lunar north. Using the four direction tick marks, find the center of the circle. Draw a line from the center through N. Next measure the angle C westward (clockwise) from N. Mark the point on the mean limb and draw a line from the center through it. This points to the Earth's north celestial pole. From this line, measure back the angle P eastward (counterclockwise) to find the point of contact on the mean limb. Draw a line from the center out through that point. Finally, from that line, measure through the angle V westward (clockwise). Draw a line from the center through this point. This line points to the observer's zenith. Now you can visualize events as follows: Facing in the direction of the Sun's azimuth (A), measured in degrees positively from the north point of the horizon around clockwise to the east, hold the diagram up at arm's length at the altitude (a) of the Sun at maximum eclipse, and turn it so that the line pointing to the zenith points straight up. The line to the north point of the disk will point to celestial north for the observing site, and the point of contact at the limb will be at its correct apparent orientation.

To get position angles for locations not listed in the tables, follow the directions given above for estimating second and third contacts, and plot the points of second and third contacts for the interpolated (P,V) *on the center line.* Draw a line connecting the two contacts on the mean limb. It should pass through the center of the disk in approximately an east/west direction. In order to transfer this line of motion to a parallel one for a point off the center line, draw or construct a perpendicular diameter, which runs approximately north/south. Taking (2b/a) from the calculation of duration, measure off (2b/a) × radius from the center of the circle along the north/south diameter in the same direction as the observing site is from the center line. Mark the point on the diameter, and draw or construct perpendicular to it, another line parallel to the line through the central line contact points. This new line will intersect the mean limb at approximately the points of contact. The eastern point is for second contact, the western is for third contact. This construction is not as accurate as a full calculation, but adequate for field estimates.

OBSERVATIONS

Precise observations of the second and third contact times, at any part of the path, but especially the northern and southern limits, are needed and requested. Since precise coordinates of the observer must be determined, reports of such timings should indicate location information, such as nearest settlement, roads to the site, distance to nearby landmarks or identifiable buildings and the nearest road intersection, distance from the center of the road, etc. The method of timing also should be described. Precision requirements are to within 0.5 seconds of time and 50 feet in location. Please send reports to:

Nautical Almanac Office
U. S. Naval Observatory
Washington, DC 20392-5100 USA

Inexperienced observers are cautioned to observe only by use of projected images, and not to use any method which would cause them to look directly at the Sun.

Information on photography, direct viewing, and projection methods may be found in the following publications:

"Safe Solar Filters," by B. Ralph Chou, *Sky & Telescope*, August 1981, p. 119.

"Observing the Sun in Safety," by J. C. D. Marsh, *J. Brit. Astron. Assoc.*, 1982, **92**, 6, p. 237.

Astrophotography Basics, Kodak Customer Service Pamphlet P-150, 1988.

A Complete Manual of Amateur Astronomy, by P. Clay Sherrod, Prentice-Hall, 1981.

Eclipse, by Bryan Brewer, 1979.

Observe: Eclipses, by R. Sweetsir and M. Reynolds, Astronomical League, 1979.

FURTHER INFORMATION

The University of Hawaii's Institute for Astronomy has published several Information Bulletins dealing with the eclipse. Request IB 89-06a, IB 89-06b, and IB 89-07 from:

The Assistant to the Director
Institute for Astronomy
University of Hawaii
2680 Woodlawn Dr.
Honolulu, HI 96822 USA

Concerning access to Mauna Kea and Mauna Loa, Charles A. Lindsey, writing in IB 89-06a, states: "For one week prior to the eclipse and for two days following it, access to the road to the summit of Mauna Kea above Hale Pohaku will be limited to scientists operating observatory facilities. The road to the Mauna Loa Solar Observatory will also be closed to the public." According to IB 89-07, restrictions on use of the road from the saddle junction to Mauna Loa Observatory will be necessary since "dust and exhaust generated by vehicles and carried by the wind to the observatory could disturb [coronal] measurements."

The Astronomical Institute of the National University of Mexico has formed a *Mexican National Committee for the 1991 Eclipse* to coordinate all scientific activities. Committee members Julieta Fierro, Daniel Flores, and Jesus Galindo, may be contacted at the following address:

Instituto de Astronomia
Universidad Nacional Autonoma de Mexico
Apartado Postal 70-264
04510, Mexico D. F. MEXICO

Inquiries concerning special calculation of local circumstances and extensions or modifications of data in this publication should be directed to the Nautical Almanac Office at the address given in the previous section.

ACKNOWLEDGEMENTS

The weather prospects section was contributed by meteorologist Jay Anderson of the Prairie Weather Centre; Winnipeg, Manitoba, Canada; (204) 983-4513.

The charts to correct contact times for the effects of lunar limb features were contributed by David Herald, Canberra, A.C.T., Australia.

The detailed maps are presented on portions of the Defense Mapping Agency's (DMA) Operational Navigation Charts (ONC) H-22, H-23, J-19, J-23, J-24, J-25, K-25, K-26, L-25, L-26, L-27, M-25, M-26, M-27, N-26, and N-27. Information concerning availability, purchase prices, and ordering instructions can be obtained by calling DMA at 1-800-826-0342 from anywhere in the continental United States, (301) 227-2495 from elsewhere, or by writing:

Director
Defense Mapping Agency CSC
ATTN: PMA
Washington, DC 20315-0010 USA

The lunar limb profile chart was prepared using software subroutines from the occultation program of the Nautical Almanac Office.

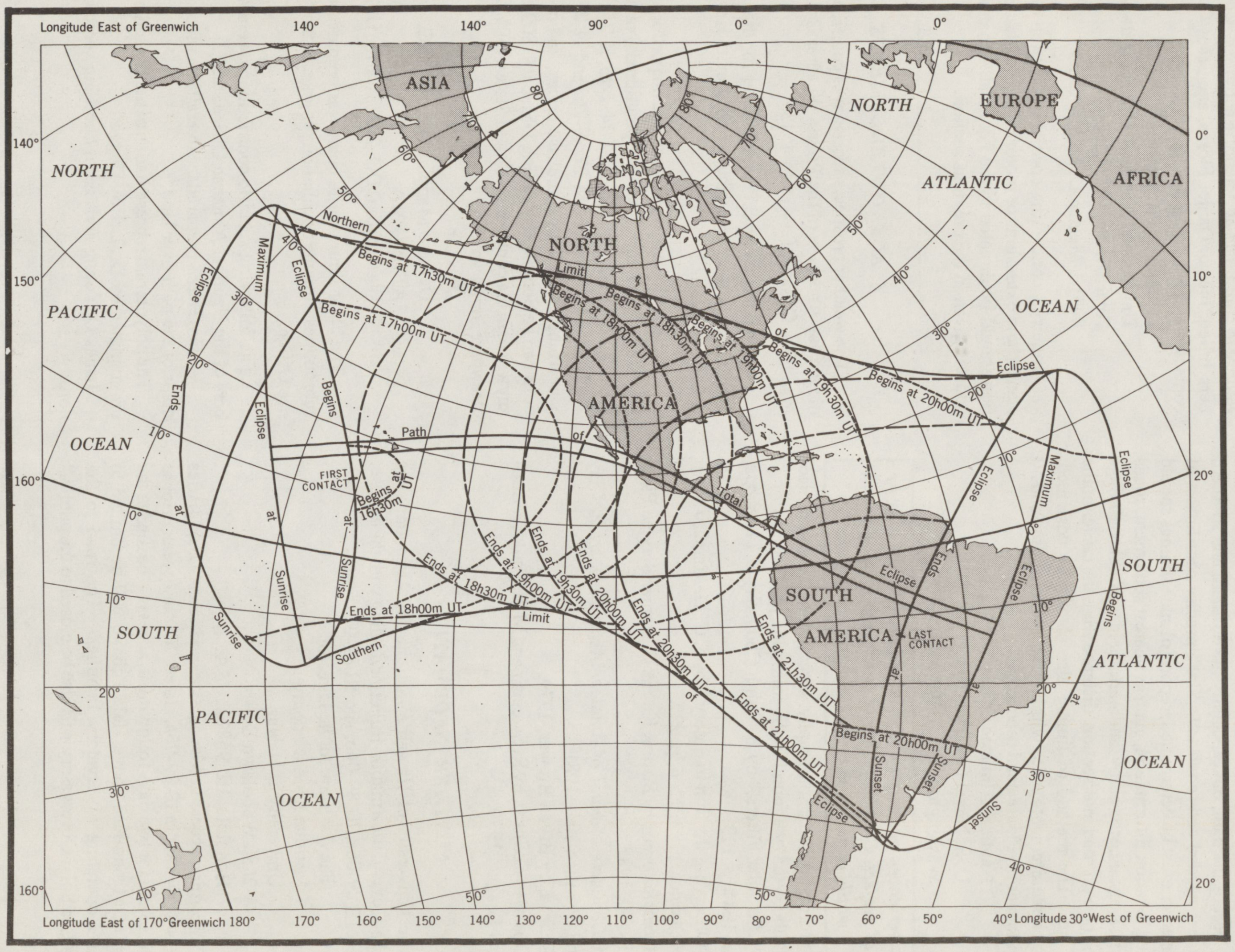
The following specific contributions were made by members of the Nautical Almanac Office staff:

William Harris prepared the overall line map and the detailed maps of the path over land.

The polynomial representation of the Besselian elements was programmed by Dr. LeRoy Doggett.

James DeYoung assisted in checking some of the calculations.

TOTAL SOLAR ECLIPSE OF 1991 JULY 11


Longitude East of Greenwich
140°
140°
90°
0°
0°
ASIA
NORTH
EUROPE
AFRICA
NORTH
ATLANTIC
PACIFIC
OCEAN
NORTH
AMERICA
SOUTH
AMERICA
SOUTH
PACIFIC
OCEAN
SOUTH
ATLANTIC
OCEAN
OCEAN
Northern Limit of Eclipse
Southern Limit of Eclipse
Path of Total Eclipse
Maximum Eclipse at Sunrise
Eclipse Ends at Sunrise
Eclipse Begins at Sunrise
Maximum Eclipse at Sunset
Eclipse Ends at Sunset
Eclipse Begins at Sunset
FIRST CONTACT
LAST CONTACT
Begins at 16h30m UT
Begins at 17h00m UT
Begins at 17h30m UT
Begins at 18h00m UT
Begins at 18h30m UT
Begins at 19h00m UT
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Ends at 21h00m UT
Ends at 21h30m UT
80°
70°
60°
50°
40°
30°
20°
10°
0°
10°
20°
30°
40°
50°
140°
150°
160°
160°
0°
10°
20°
20°
Longitude East of 170°Greenwich 180°
170°
160°
150°
140°
130°
120°
110°
100°
90°
80°
70°
60°
50°
40° Longitude 30°West of Greenwich

SURFACE PATH OF THE TOTAL PHASE

U.T.	Northern Limit		Central Line		Southern Limit	
	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
	° ′	° ′	° ′	° ′	° ′	° ′
Limits	+13 18.8	−175 02.3	+12 28.7	−174 36.6	+11 38.5	−174 11.4
h m						
17 24	+15 23.6	−169 59.1	+15 04.1	−168 12.1	+14 34.8	−166 48.1
17 25	+16 56.6	−166 06.9	+16 22.0	−164 53.2	+15 43.2	−163 49.5
17 30	+20 29.5	−156 37.2	+19 39.8	−155 52.5	+18 48.5	−155 11.9
17 35	+22 25.7	−150 44.6	+21 30.4	−150 09.0	+20 34.2	−149 36.6
17 40	+23 45.9	−146 06.5	+22 47.1	−145 37.0	+21 47.7	−145 10.3
17 45	+24 44.8	−142 09.5	+23 43.5	−141 45.1	+22 41.6	−141 23.2
17 50	+25 28.9	−138 39.5	+24 25.4	−138 19.7	+23 21.7	−138 02.1
17 55	+26 01.4	−135 28.9	+24 56.4	−135 13.4	+23 51.1	−134 59.8
18 00	+26 24.7	−132 33.1	+25 18.4	−132 21.7	+24 11.9	−132 11.9
18 05	+26 40.1	−129 49.2	+25 32.8	−129 41.7	+24 25.4	−129 35.6
18 10	+26 48.8	−127 15.0	+25 40.7	−127 11.3	+24 32.6	−127 08.8
18 15	+26 51.4	−124 49.0	+25 42.8	−124 48.9	+24 34.1	−124 50.0
18 20	+26 48.5	−122 30.0	+25 39.6	−122 33.5	+24 30.7	−122 37.9
18 25	+26 40.7	−120 17.1	+25 31.6	−120 24.1	+24 22.6	−120 31.7
18 30	+26 28.3	−118 09.6	+25 19.3	−118 19.9	+24 10.3	−118 30.6
18 35	+26 11.6	−116 06.9	+25 02.8	−116 20.3	+23 53.9	−116 34.1
18 40	+25 50.9	−114 08.3	+24 42.4	−114 24.8	+23 33.9	−114 41.4
18 45	+25 26.4	−112 13.5	+24 18.3	−112 32.9	+23 10.3	−112 52.3
18 50	+24 58.2	−110 22.1	+23 50.7	−110 44.2	+22 43.2	−111 06.2
18 55	+24 26.6	−108 33.6	+23 19.8	−108 58.3	+22 12.9	−109 22.8
19 00	+23 51.5	−106 47.7	+22 45.5	−107 14.8	+21 39.4	−107 41.6
19 05	+23 13.2	−105 04.0	+22 08.0	−105 33.4	+21 02.8	−106 02.4
19 10	+22 31.6	−103 22.1	+21 27.4	−103 53.7	+20 23.0	−104 24.7
19 15	+21 46.9	−101 41.8	+20 43.6	−102 15.3	+19 40.3	−102 48.2
19 20	+20 58.9	−100 02.6	+19 56.8	−100 37.9	+18 54.4	−101 12.6
19 25	+20 07.8	− 98 24.1	+19 06.8	− 99 01.2	+18 05.5	− 99 37.5
19 30	+19 13.5	− 96 45.9	+18 13.6	− 97 24.6	+17 13.4	− 98 02.4
19 35	+18 15.9	− 95 07.6	+17 17.2	− 95 47.7	+16 18.1	− 96 27.0
19 40	+17 15.0	− 93 28.7	+16 17.4	− 94 10.1	+15 19.5	− 94 50.7
19 45	+16 10.5	− 91 48.6	+15 14.2	− 92 31.2	+14 17.4	− 93 12.9
19 50	+15 02.2	− 90 06.6	+14 07.2	− 90 50.4	+13 11.6	− 91 33.1
19 55	+13 50.0	− 88 21.9	+12 56.2	− 89 06.8	+12 01.9	− 89 50.5
20 00	+12 33.5	− 86 33.7	+11 40.9	− 87 19.5	+10 47.8	− 88 04.2
20 05	+11 12.1	− 84 40.7	+10 20.9	− 85 27.4	+ 9 29.1	− 86 13.0
20 10	+ 9 45.4	− 82 41.5	+ 8 55.5	− 83 29.1	+ 8 05.0	− 84 15.5
20 15	+ 8 12.5	− 80 34.1	+ 7 24.0	− 81 22.6	+ 6 34.7	− 82 09.9
20 20	+ 6 32.1	− 78 15.9	+ 5 45.1	− 79 05.3	+ 4 57.2	− 79 53.3
20 25	+ 4 42.6	− 75 42.8	+ 3 57.2	− 76 33.2	+ 3 10.8	− 77 22.2
20 30	+ 2 41.3	− 72 48.6	+ 1 57.6	− 73 40.4	+ 1 12.9	− 74 30.5
20 35	+ 0 23.3	− 69 22.6	− 0 18.2	− 70 16.3	− 1 00.9	− 71 08.1
20 40	− 2 21.0	− 65 02.1	− 2 59.5	− 65 59.3	− 3 39.5	− 66 54.0
20 45	− 6 00.8	− 58 39.4	− 6 33.1	− 59 46.5	− 7 07.7	− 60 49.4
20 46	− 7 00.0	− 56 47.9	− 7 29.6	− 58 00.1	− 8 02.1	− 59 07.1
20 47	− 8 11.5	− 54 27.4	− 8 36.5	− 55 49.2	− 9 05.5	− 57 03.2
20 48	− 9 51.8	− 50 58.4	−10 04.8	− 52 47.3	−10 26.0	− 54 18.3
Limits	−12 08.5	− 45 47.0	−12 58.4	− 46 12.5	−13 48.3	− 46 37.7

For duration, path width, and altitude and azimuth of the Sun,
please see page 22, **Local Circumstances for Points on the Central Line**

ELEMENTS OF THE ECLIPSE

U.T. of geocentric conjunction in right ascension, July $11^{d}\ 19^{h}\ 06^{m}\ 8^{s}.515$

Julian Date = 2448449.2959318864

	h m s		s		s
R.A. of Sun and Moon	7 22 12.791	Hourly motions	10.196	and	159.902
ΔT	57.540				
	° ′ ″				′ ″
Declination of Sun	+22 05 48.50	Hourly motion			− 0 19.99
Declination of Moon	+22 05 32.72	Hourly motion			− 8 46.34
Equatorial hor. par. of Sun	8.65	True semidiameter of Sun			15 43.9
Equatorial hor. par. of Moon	61 17.72	True semidiameter of Moon			16 42.2
Lunar figure offset, long.	+ 0.54				
Lunar figure offset, lat.	− 0.28				

CIRCUMSTANCES OF THE ECLIPSE

		U.T.		Longitude	Latitude
		d	h m	° ′	° ′
Eclipse begins	July	11	16 28.7	−161 00.4	+12 32.5
Central eclipse begins		11	17 23.3	−174 36.6	+12 28.7
Central eclipse at local apparent noon		11	19 06.1	−105 10.5	+21 59.0
Central eclipse ends		11	20 48.8	− 46 12.5	−12 58.4
Eclipse ends		11	21 43.4	− 59 48.9	−12 54.6

Longitudes are measured positive East.

BESSELIAN ELEMENTS, POLYNOMIAL FORM

The equations below represent simple least-squares fits to the tabular Besselian Elements.

Let t= U.T. in hours defined from 16^{h} U.T. on 11 July 1991. These equations are valid over the range $0^{h}.383 \leq t \leq 5^{h}.892$. Do not use t outside the given range, and do not omit any terms in the series.

$$\begin{aligned}
x &= -1.75954169 + 0.56710171\,t + 0.00004902\,t^2 - 0.0000960\,t^3 \\
y &= 0.42232901 - 0.13699808\,t - 0.00017527\,t^2 + 0.0000250\,t^3 \\
\sin d &= 0.37643393 - 0.00008389\,t - 0.00000010\,t^2 \\
\cos d &= 0.92644352 + 0.00003404\,t + 0.00000004\,t^2 \\
\mu &= 58.63895810 + 15.00004860\,t + 0.00000165\,t^2 - 0.00000002\,t^3 \\
\text{Radius penumbra} &= 0.53024501 + 0.00010153\,t - 0.00001278\,t^2 \\
\text{Radius umbra} &= -0.01606000 + 0.00010100\,t - 0.00001272\,t^2
\end{aligned}$$

BESSELIAN ELEMENTS

U.T.	Intersection of Axis of Shadow with Fundamental Plane		Direction of Axis of Shadow			Radius of Shadow on Fundamental Plane	
	x	*y*	sin *d*	cos *d*	μ	Penumbra	Umbra
h m					°		
16 00	−1.759541	+0.422329	+0.376434	0.926443	58.63896	0.530245	−0.016060
10	1.665023	0.399491	.376420	.926449	61.13897	.530262	.016044
20	1.570503	0.376644	.376406	.926455	63.63897	.530277	.016028
30	1.475980	0.353786	.376392	.926461	66.13898	.530293	.016013
40	1.381455	0.330920	.376378	.926466	68.63899	.530307	.015998
50	1.286928	0.308044	.376364	.926472	71.13900	.530321	.015985
17 00	−1.192401	+0.285158	+0.376350	0.926478	73.63901	0.530334	−0.015972
10	1.097872	0.262263	.376336	.926483	76.13902	.530346	.015959
20	1.003342	0.239359	.376322	.926489	78.63903	.530358	.015948
30	0.908811	0.216446	.376308	.926495	81.13903	.530369	.015937
40	0.814280	0.193524	.376294	.926500	83.63904	.530379	.015927
50	0.719750	0.170592	.376280	.926506	86.13905	.530388	.015918
18 00	−0.625219	+0.147652	+0.376266	0.926512	88.63906	0.530397	−0.015909
10	0.530689	0.124702	.376252	.926517	91.13907	.530405	.015901
20	0.436159	0.101744	.376238	.926523	93.63908	.530412	.015894
30	0.341631	0.078777	.376224	.926529	96.13909	.530419	.015887
40	0.247104	0.055802	.376210	.926535	98.63910	.530425	.015881
50	0.152578	0.032818	.376195	.926540	101.13911	.530430	.015876
19 00	−0.058055	+0.009825	+0.376181	0.926546	103.63912	0.530435	−0.015871
10	+0.036467	−0.013176	.376167	.926552	106.13913	.530438	.015868
20	0.130986	0.036186	.376153	.926557	108.63914	.530441	.015865
30	0.225503	0.059204	.376139	.926563	111.13915	.530444	.015862
40	0.320017	0.082231	.376125	.926569	113.63916	.530445	.015861
50	0.414528	0.105265	.376111	.926575	116.13917	.530446	.015860
20 00	+0.509035	−0.128308	+0.376097	0.926580	118.63918	0.530447	−0.015859
10	0.603538	0.151358	.376083	.926586	121.13919	.530446	.015860
20	0.698038	0.174417	.376069	.926592	123.63920	.530445	.015861
30	0.792534	0.197484	.376055	.926598	126.13921	.530443	.015863
40	0.887025	0.220558	.376040	.926603	128.63922	.530440	.015866
50	0.981511	0.243641	.376026	.926609	131.13923	.530437	.015869
21 00	+1.075992	−0.266731	+0.376012	0.926615	133.63924	0.530433	−0.015873
10	1.170468	0.289829	.375998	.926620	136.13925	.530428	.015878
20	1.264938	0.312934	.375984	.926626	138.63926	.530423	.015883
30	1.359403	0.336047	.375970	.926632	141.13927	.530417	.015889
40	1.453861	0.359167	.375956	.926638	143.63928	.530410	.015896
50	1.548314	0.382295	.375942	.926643	146.13929	.530402	.015904
22 00	+1.642759	−0.405429	+0.375927	0.926649	148.63930	0.530394	−0.015912
22 10	+1.737198	−0.428572	+0.375913	0.926655	151.13932	0.530385	−0.015921

tan f_1	0.004599	
tan f_2	0.004576	
μ'	0.261800	radians per hour
d'	−0.000091	radians per hour

WEATHER PROSPECTS FOR THE ECLIPSE

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AN OVERVIEW OF THE WEATHER PATTERNS

With a track that ranges from 27° north of the equator to 14° south, the eclipse occurs entirely within the equatorial and sub-tropical regions of the Earth. On July 11 the northern hemisphere summer is nearly at its peak, and the rainy season is well established above the equator. At the end of the track in central Brazil, the winter dry season is solidly entrenched.

The eclipse begins over the central Pacific southwest of Hawaii and follows a track along the south edge of the semi-permanent sub-tropical anticyclone (high) which resides along the 30th parallel (Figure 1). Until it reaches the Baja coast, the track is embedded in the northeast trade wind flow which circulates around the anticyclone. This trade wind zone is characterized by a persistent low level inversion which traps moisture evaporated from the warm waters of the Pacific and creates an area of extensive low level cloudiness between Hawaii and the North American coast. The central pressure of the anticyclone reaches its maximum during the month and the trade wind circulation is steady and strong.

As the Moon's shadow crosses Mexico it leaves the steady trade winds and enters a region dominated by a weak low pressure cell lying the length of Central America. Convective cloudiness increases markedly as the stable inversion regime gives way to a more unsettled atmosphere. Much of Mexico is at the height of its rainy season with frequent afternoon showers and thundershowers and thickening cloud cover at eclipse time. The rainy season in the north, except for Baja, has a single peak in July, but south of Mexico City and through Central America the rainfall has a double peak, in June and September, making July a slightly drier month.

Continuing southward, the eclipse track approaches and then passes the Intertropical Convergence Zone (ITCZ). As its name suggests, it is a region where the wind flows from the north and south hemispheres gradually merge, giving rise to a band of heavy cloudiness and considerable thunderstorm activity. As a rule the activity on the ITCZ is quite variable, except over the ocean west of Panama and along the west coast of Colombia. Satellite images show heavy cloud clusters in the area year after year in July (Figure 2). This area of the ITCZ is the most active on the globe in July and the eclipse track crosses through its midst.

Through Colombia and into northern Brazil the ITCZ is broken up by the high Andes mountains and its influence is spread across the whole of northern South America. After descending the eastern slopes of the Andes and leaving the Amazon basin of Brazil, the lunar shadow speeds into a drier and much sunnier portion of the continent. The sub-tropical high which presides over the south Atlantic brings subsiding air and stable inversion conditions to the end of the track, much as its Hawaiian counterpart did at the beginning.

REGIONAL CLIMATOLOGY IN DETAIL

Hawaii

Weather in Hawaii is at the mercy of the winds. The islands are embedded in the steady northeast trade winds which bring moist tropical air and Pacific cloudiness onto the lava slopes. The Big Island is marked by two volcanic bulwarks, Mauna Loa and Mauna Kea, rising above the winds like boulders in a stream. Linking the two peaks is an immense wall of high ground 2000 metres above sea level, the Humu'ula Saddle.

The trade wind inversion is usually found between 1800 and 2400 metres, and rarely as high as 4500 metres above the Pacific. It acts as a lid on the atmosphere, confining moisture, cloud, and haze to the lower slopes while a clean, dry and steady atmosphere sparkles on the peaks above. As long as the trade winds are blowing the inversion will be there. And the trades are very reliable, blowing nearly 95% of the time in July.

The moisture carried by the winds onto the volcanic slopes makes the eastern side of the island an area of heavy cloud and rainfall. It is a highly variable pattern of cloudiness, depending each day on the precise direction and strength of the winds and the amount of moisture in the air. Areas most prone to morning cloudiness are those in the direct path of the wind, where the air is forced to climb the mountain slopes. Rising air cools, reaches saturation, and forms clouds. But air on the mountain tops also cools overnight, flowing downhill and drying, meeting the rising moisture of the trades (Figure 3).

The cool downhill flow from higher levels undercuts the rising trade wind flow and gives an additional impetus to its ascent. If the trade winds are lighter than usual, the meeting point is over the water east of the island, forming a long arc of cloudiness which resembles the bow wave of a speedboat. In such cases the entire island may be clear as the sun rises in the morning. But more likely the meeting of winds will take place on the lower slopes of Mauna Loa and Mauna Kea, bringing heavy nighttime cloudiness to the windward beaches. The downhill flow from the volcano is a shallow one, only tens to hundreds of metres in depth, and above it the easterly trades continue to blow up the slopes, forming a second area of cloudiness at a higher level. Satellite pictures often show the two areas of cloudiness, though more commonly they are merged into one large cloud cluster. But one feature stands out – the higher reaches above the inversion, and the sheltered lee of the island are likely to be clear. And this is where eclipse viewing has its best prospects.

As the sun rises the eastward facing slopes are warmed first. The air against the ground changes direction and begins to rise, carrying the moisture and cloud to a higher level and pushing the inversion upward. A shallow layer of cloud begins to flow uphill until it mixes with drier air above and evaporates. This creeping upslope morning cloud is colloquially referred to as *caterpillar* *cloud*. The best eclipse sites should be located a little above the inversion to avoid being caught by this morning interloper. Fortunately, upslope winds do not normally begin until about 9 a.m. on the volcanic slopes and should be even later on eclipse day.

The leeward side of the island is much less cloudy in the morning, for the trade winds are blowing downhill and drying, reinforcing the usual drainage flow. The distinction is quite pronounced, as a shift of only a few miles from the east to the west side of the Saddle may mean the difference between overcast and clear skies (Figure 4a). On the western beaches, near Kailua Kona, an eddy in the circulation around the islands occasionally brings moist air onshore, and cloud can form at lower levels due to a local upslope flow. This cloud is usually fairly limited in extent since the eddy is relatively weak.

At higher levels cirrus cloudiness can be a more widespread problem. Cirrus is an ice crystal cloud formed high in the atmosphere where temperatures are low. Such clouds are often transparent and could allow the eclipse to be seen in hazy skies, though probably obscuring much of the corona. Cirrus and middle level water clouds are carried over Hawaii from the ITCZ, which lies an average of 1500 kilometres to the south. Under disturbed conditions, upper level winds may turn to the south and southwest, carrying the high level cloud from the ITCZ thunderstorms over the islands. Such cloud does not wax and wane through the day and would likely linger through the eclipse without dissipating. It probably represents the most serious threat to the eclipse chaser who is otherwise sited away from the low level cloud. However an examination of satellite imagery for the month from 1983 to 1988 showed broken to overcast high cloud at eclipse time an average of only two days per month.

Hurricanes and tropical storms pose another threat to shadow-chasers, albeit a rare one. These storms form in the warm waters off Central America and travel northeastward toward the Hawaiian islands, usually dissipating along the way. Occasionally one of the storms makes it right to the islands, passing close enough to spread cirrus and even overcast mid level cloud across the peaks. Fortunately the probability is very low – in the 37 years from 1950 to 1987 only eight July storms have passed within 600 kilometres of the Big Island. Two were of hurricane intensity.

On rare July days when the trade winds are absent, winds tend to shift to a southerly direction and the inversion weakens or disappears. The windward side of the island is now to the south and west so that the upslope flow brings heavy morning cloud cover to areas which are usually clear. Convective clouds, unconstrained by the inversion, grow to high altitudes in the afternoon, above the volcanic summits, bringing heavy precipitation and occasionally thunder and lightning. Downslope winds and sunnier skies would then be found on the Hilo side of the saddle, reversing the pattern of cloudiness typical of trade wind days.

While the upper slopes of Mauna Kea are expected to be closed to the public on eclipse day there are many good viewing sites at lower altitudes. One is at Puhakuloa, just west of the Humu'ula Saddle and about 2000 metres above sea level. While below the usual level of the trade wind inversion, it is on the downslope side of the volcanic barriers, in the region where clouds tend to dissipate. Since this is an early morning eclipse, travel to the observing site will be at night or the morning twilight for those unable to stay on the mountain. Approaches from the Hilo side may have to navigate through fog clinging to the mountain sides before breaking through to the drier air aloft. Fog is less likely if the approach to Puhakuloa is made from Waimea.

For those who wish to wait for the lunar shadow from lower altitudes, much of the west side of the island offers good prospects. The best is probably in the vicinity of Kailua Kona, but keep an escape route in mind – perhaps north along Palani Road and the Mamalahoa Highway – because cloud does occasionally creep ashore along this coast. Because these cloud patches are likely to be limited in extent, a few scouts placed nearby with access to a telephone may be all that is needed to find a sunny location. Make sure the sun is visible from your site throughout the eclipse, and not tucked behind the terrain, or subject to being hidden by early morning clouds developing over a nearby hill.

Mexico

With the rainy season well advanced in July, cloud cover across much of Mexico is heavy and widespread. The exception is the Baja Peninsula which is protected from the moist easterly trades in the low levels by the mainland mountains. The wind's direction over Baja California Sur tends to be northerly, on the edges of the Pacific high, and the atmosphere is stabilized by the windflow over the cool California current and the weak marine inversion which still persists at the peninsula's latitude.

In the evening the thunderstorms over the Sierra Madres reach their greatest intensity, climbing 15 kilometres into the atmosphere. As night continues these cloud buildups gradually subside, leaving a patchwork quilt of mid and high level cloudiness across the country. East and southeast winds at high levels catch this debris cloud and push it toward Baja, gradually thinning as it moves across the Gulf of California. Morning may reveal the remnant of the high cloud, sometimes as thin patches, sometimes as great cloudy masses covering the sky. As the day warms toward the hour of the eclipse the cloud continues to thin, usually evaporating completely before the lunar shadow is due.

But on some days the upper disturbances are a little stronger, the air a little wetter, the drying a little slower. Cloud cover lingers into the afternoon, past the appointed time for the eclipse, sometimes building new convective showers on the Baja Peninsula itself. In the past five years it has happened an average of 5 days per month – not much, but a cause for concern since there is very little room for movement away from weather systems on the narrow spike of land. Shipboard observations offer a more flexible option, provided accurate weather forecasts can be obtained in time to move. But the movement and dissipation of thunderstorm debris is difficult to predict, so action will likely have to be taken at short notice. Because of its height, observers will be able to see the cloud from great distances and gain some knowledge of its movement, so that finding an open or thin spot will be easier.

The south tip of the Baja Peninsula is crossed by a small range of mountains known as the Sierra de Santa Lazaro, running from La Paz to Cabo San Lucas. Angled toward the morning sun, the eastern slopes are warmed early in the day, promoting rising air currents which cool and become saturated. On most July mornings the rising currents build a line of convective clouds on the hills which may grow into small thunderstorms by mid afternoon. While the first clouds, if any, will form before the start of the eclipse, it is likely that the fall in temperature as the sun is masked will cause them to dissipate between first and second contact. Statistics compiled from thirty years of surface observations show that the Pacific coast of the Baja is slightly less cloudy than that along the Gulf of California.

Shipboard travellers will have the advantage of easy movement if the skies around Baja turn cloudy. Cloudiness over the Gulf of California is a little heavier than Baja (Figure 4b) and Pacific coast waters are occasionally pestered by patchy low cloud and fog. This is not as common in July as a month earlier and should be relatively easy to avoid. Wave heights average less than 1 metre within the confined waters of the Gulf of California, and about 1.5 metres on the Pacific side. Observers positioned on the Pacific beaches should keep a wary eye out for fog offshore, as this can be carried inland by sea breeze winds in the morning. Relocating to a few kilometres inland should be sufficient to escape.

The warm waters south of Baja are the spawning grounds for tropical storms, and July is the second most frequent month of their occurrence. Eastern Pacific tropical storms tend to be smaller and weaker than their counterparts elsewhere in the world and about one in 20 recurves eastward to strike the west coast of Mexico in the vicinity of Baja. Between 1979 and 1987 eight tropical cyclones passed within 600 kilometres of the Baja eclipse track, two with hurricane intensity. None scored a direct hit, though Hurricane Greg crossed the track near the mainland coast in 1987. As with Hawaii, they are a minor risk with dramatic consequences should they be unfortunate enough to move onto the eclipse track. Movement, especially on water, could be severely curtailed as the storm approaches.

Other locations in Mexico suffer from the large frequency of thunderstorms and accompanying cloudiness which Baja usually escapes. The early afternoon passage of the eclipse will see most convective clouds in a growing state of development. In contrast to smaller buildups, clouds which have started to precipitate or are on the verge of doing so, are unlikely to dissipate as the air cools. After Baja the best locations for viewing the sun are on the coasts – either south of Mazatlan or on the Gulf of Tehuantepec (Table 1). In the interior clouds build first on the east slopes of the mountains, and locations to the west offer better prospects. The range of peaks between Guadalajara and Mexico City are very cloudy but slightly drier weather can be found northeast of Guadalajara towards Aguascalientes. The centre line crosses to the west side of the Sierra Madre Oriental near Puebla where slightly better chances of clear skies can be found. Mobility would be of considerable advantage.

The average cloud amount in July ranges from 60 to 70% in the interior, versus about 33% at Baja. More useful in eclipse site planning is the frequency of scattered, broken and overcast cloudiness, which can be more directly related to the chances of seeing the eclipse. A rough measure of the probability of seeing the eclipse at particular location is to add 90% of the frequency of scattered conditions to 50% of the broken cloud frequency and 10% of the overcast frequency. The climate statistics for Baja show that 52% of the daytime observations in July had completely clear skies. The corresponding figure for the mainland part of Mexico is 2 to 6%. The frequency of clear skies at Baja for July is twice that of any other region in North America.

Central America

Southward from Mexico the eclipse track approaches the location of the ITCZ with its high levels of cloudiness and frequent precipitation. Local time of totality is now in the early afternoon hours and the sun has had ample opportunity to warm the lower atmosphere. Cumulus cloud buildups reach their maximum extent by 2 p.m. while thundershowers continue to grow to a maximum 2 to 5 hours later. The mountainous backbone to the isthmus modifies the cloudiness by promoting cloud development on windward slopes, and reducing it to leeward, but winds are typically very light and subject to great local variation. Dryer and wetter sides of the terrain will have to be investigated locally. Occasionally vegetation will be a clue as to where rain is least likely.

The centre line is accessible from land only in Guatemala, Costa Rica and Panama. Of these, the Pacific coast of Guatemala is most likely to have sunny skies, as the presence of the ITCZ in more southerly regions contributes substantially to the mean cloud cover. The easing of the rainy season in July, known locally as the *veranillo* ("little summer") is more pronounced in Guatemala and sunshine is a little more abundant than in June or September. At San Salvador July sunshine averages an encouraging 60% of the maximum possible, while in June it is a meagre 45% and in September, 49%.

The Pacific coast is also subject to the effects of an occasional tropical depression, known as a *temporal*. These weak low pressure systems bring long lasting rains and heavy cloud cover which would be disastrous to an eclipse expedition. Temporals are most common in June, September, and October. Each location on the coast can expect one or two a year.

Colombia

Weather in Colombia is similar to that in Central America, as the continental extension of the ITCZ and equatorial trough lies across the country in July. However Colombia is a region of great variation in terrain, and weather conditions are equally variable between the coastal lowlands and the interior Andean peaks. The path of the eclipse crosses three climatic regions: the Pacific coast, the Andean region, and the Amazon.

The Pacific coast region is one of the wettest locations on the Earth with an average rainfall which reaches 5500 millimetres annually. Sunshine is most likely to be found from midmorning to mid-afternoon along the coastline. Since the lunar shadow reaches the area around 3 p.m. local time, it has to be considered among the least favourable to pick for a viewing site.

The Andean section is a region of great contrasts, with three mountains ranges which reach altitudes above 5000 metres. Two valleys separate the ranges: the westernmost contains the Cauca River and the city of Cali, while the eastern constrains the Magdalena River and the city of Neiva. The Andes section has been likened to a dry island in a sea of rain.

Precipitation amounts within the valleys are approximately a tenth those on the coast in July, with the Cauca generally the drier, being higher and narrower than the Magdalena. Unfortunately rainfall tends to occur most often in the mid-afternoon – right at eclipse time. Table 1 shows the characteristics of precipitation and cloud cover in the area.

East of the Andes, in Amazonia, precipitation and cloudiness are heavy the year round. Poor access routes and a propensity for cloud cover to be heaviest at eclipse time makes this another poor choice as a viewing site.

Brazil

Leaving Colombia, the shadow track crosses the Amazon plains and comes to its sunset finale over the Planalto Central north of Brasilia. Areas south of the equator are primarily under the influence of the sub-tropical anticyclone resident over the south Atlantic, which is also at its strongest in July. As in the northern hemisphere between Hawaii and Baja, the low level flow from this high is capped by a strong inversion. The inversion suppresses the development of convective cloudiness and gives a great abundance of sunshine to east central sections of the country. The moisture which is normally trapped under the inversion is removed as the air crosses the coastal mountains on its way to the central plains.

At the end of the eclipse track, near Brasilia, the greatest sunshine amounts are recorded in August, with July close behind. Manaus, on the Amazon River, averages nearly 220 hours of sunshine in July. Porto Nacional, at the end of the track, averages almost 100 hours more. However skies are often hazy in July, with reduced visibilities reported an average of 3-9 days per month.

SUMMARY

Three areas stand out as having high frequencies of sunshine in the climatological record – parts of Hawaii, the Baja Peninsula, and central Brazil. Of these, the higher altitudes of Hawaii appear most likely to allow a successful view of the event. Nevertheless, all regions have weather patterns which could bring cloud cover during the show. Escape to a sunnier position is probably easiest in Hawaii and most difficult in the Baja, but mobility should be a consideration for all viewers.

One of the greater problems in the selection of an eclipse site is the formation of cloud, usually low cloud, between first and second contact. Cloud cover can develop as a result of cooling of a moist layer, or the advection of moisture from a wetter location upwind. Often the cooling of the air during the eclipse itself is enough to bring on saturation. Some studies have suggested that the shock set up in the atmosphere by the passage of the lunar shadow is sufficient to cause cloud to form, though this is expected to occur after the main event is over. And even though convective clouds may dissipate, the moisture which fed them still persists in the lower atmosphere and can turn into an obscuring blanket at the last moment.

To maximize the possibility of a clear sky during the eclipse some attempt to avoid these effects should be made, especially since much of the land area crossed by this eclipse is supplied by generous amounts of water vapour. Try to locate at a site where winds blow downhill – not right at the bottom of a hill or valley, but a little bit up the side. Be aware that the winds will likely drop, and may change direction as the shadow approaches. Visit the site the evening before to get a feeling for such changes. If your sky is full of small cumulus clouds before the eclipse, you are in danger of clouding over at totality, even though the cloud may dissipate at first. In such cases avoid positions with upslope winds completely. Watch the cumulus to see which way it is moving as it will tell you the wind directions aloft. Also watch out for building showers and thundershowers in the direction of the sun, as these may grow to block your view at totality. Plan before the eclipse is underway, so that the excitement of the moment doesn't push the consideration of cloudiness out of your mind.

Even in sites with poorer climatological prospects, many if not most observers will see at least some of the eclipse. Careful planning will go a long way to putting your observation in with that group.

Table 1: Climate Statistics Along the Eclipse Track.

Location	Temperature		Meas. Precip. in July	Mean Precip.	Mean Cloud Cover	<0.3 Cloud Cover and Good Visibility	Scattered Cloud Cover	Broken Cloud Cover	Overcast Cloud Cover	Days with Fog	Hours of Sunshine	Frequency of Clear Skies
	Mean Max.	Mean Min.										
	°C	°C	Days	mm	%	Days	Days	Days	Days	Days		%
Hilo	28	19	12.5	246	77		1	12	18	0.0		0
Puerto Cortez	29	20	0.4	3			21.1	9.4	0.6	1.2		52
La Paz	36	23	1.5	13			14.2	13.8	2.9	0.0		52
Mazatlan	30	26	13.1	154			1.6	15.2	14.2	0.0	212	6
Tuxpan	33	25	16.4	275			8.2	16.7	6.1	0.0		4
Tepic	29	19	19.9	379			0.4	11.9	18.6	0.5		4
Guadalajara	26	15	22.8	250			1.7	10.9	18.4	2.1	188	4
Mexico City	23	11	22.8	156			0.9	11.3	18.8	2.8	193	2
Puebla	23	12	17.4	128			4.1	17.3	9.6	0.2		2
Oaxaca	29	15	14.4	80			1.7	15.9	13.4	3.2	165	2
Salina Cruz	33	24	9.8	176			4.6	14.9	11.5	0.1	204	2
Tonala	33	27	15.9	306			4.5	7.9	18.6	0.0		2
Tapachula	33	19	23.6	367			1.2	15.1	14.7	0.1	167	2
Guatemala City	25	15	21	211	83	0.0	2.5	19.2	9.6*	1.9		1
San Salvador	32	18	15.7	304	74	3.2	2.5	19.2	9.6*		239	0
San Jose	25	17	23	211		0.0	1.6	20.2	9.2*	1.0		0
David	31	22	13.0	287		0.5	1.6	20.2	9.2*	1.0		0
Andagoya	28	24	24.4	572			1.6	15.4	14.0*			1
Cali	25	17		61		0.6	1.6	15.4	14.0*			1
Tulua	32	19		25		0.4	1.6	15.4	14.0*	0.0		1
Espinal			2.0	45			1.6	17.9	11.5*			1
Bogota	18	10	18.0	47	87	0.6	1.6	17.9	11.5*	6.0	130	1
Mitu				424		0.0	1.9	21.1	8.0*			1
Uaupes			21	234	74		2.8	21.7	6.5*	9	163	4
Manaus	32	23	8	64	57	4.0	8.1	19.5	3.4*	2	238	11
Porto Nacional	34	17	0	3	59	17.2	17.1	12.1	1.8*	0	307	44
Formosa	26	11	1	4	35		15.8	12.7	2.5*	5	295	44

Note: Over Mexico, scattered cloud implies one third or less sky cover, broken is one to two thirds cloud cover and overcast is more than two thirds cloudiness. Elsewhere scattered refers to 0-2 tenths cloud, broken is 3-7 tenths cloud and overcast is 8-10 tenths. An asterisk (*) indicates that the data is derived from satellite imagery, and is valid for the area around the station location. Stations are arranged in their order along the eclipse track.

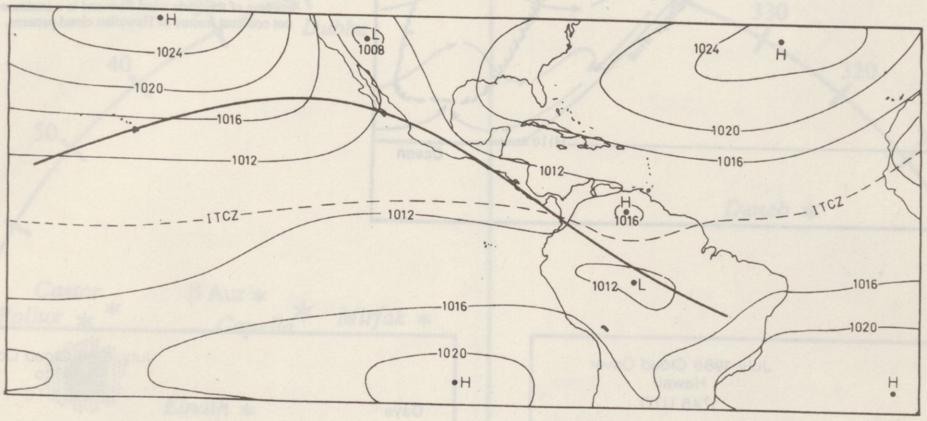
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Figure 1: Mean sea level pressure (millibars) for July. The dashed line marks the mean position of the Intertropical Convergence Zone (ITCZ).

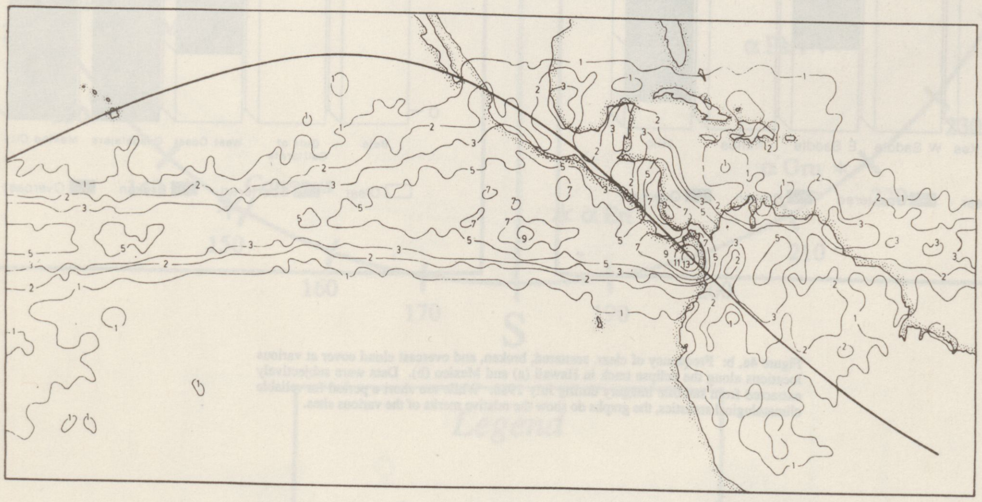


Figure 2: Mean number of days in July with highly reflective clouds (HRC) in a location. HRC represent large thunderstorm clusters which appear as bright cold circular areas in satellite images of the tropics. They are responsible for much of the rainfall and a significant portion of the cloudiness of equatorial regions. (from Atlas of Highly Reflective clouds for the Global Tropics, 1971-1983; U.S. Dept. of Commerce).

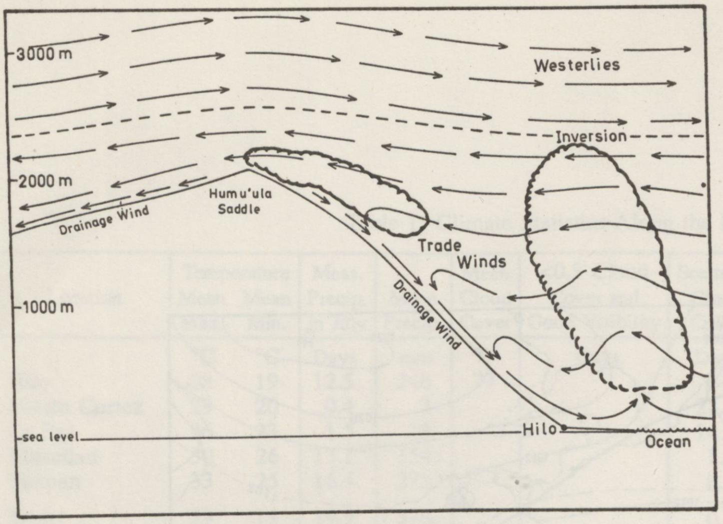

3000 m
Westerlies
Inversion
2000 m
Humu'ula Saddle
Drainage Wind
Trade Winds
Drainage Wind
1000 m
sea level
Hilo
Ocean

Figure 3: Cross section through the Humu'ula Saddle showing typical sunrise wind flow patterns on the volcanic slopes of Hawaii. Drainage winds are light at the saddle and strengthen as they move downhill. Cloud cover forms near Hilo as a result of the convergence of trade and drainage winds. Cloud on the volcanic slopes is due to orographic cooling of the trade wind flow and is a common but not constant feature of Hawaiian cloud patterns.

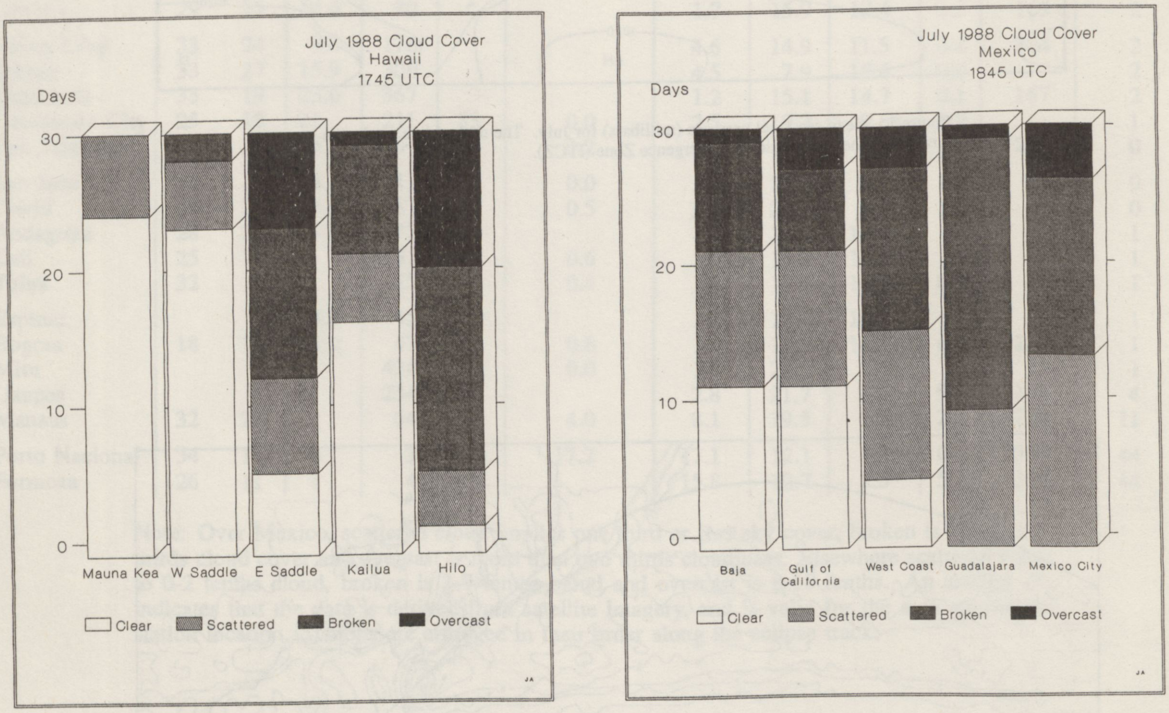
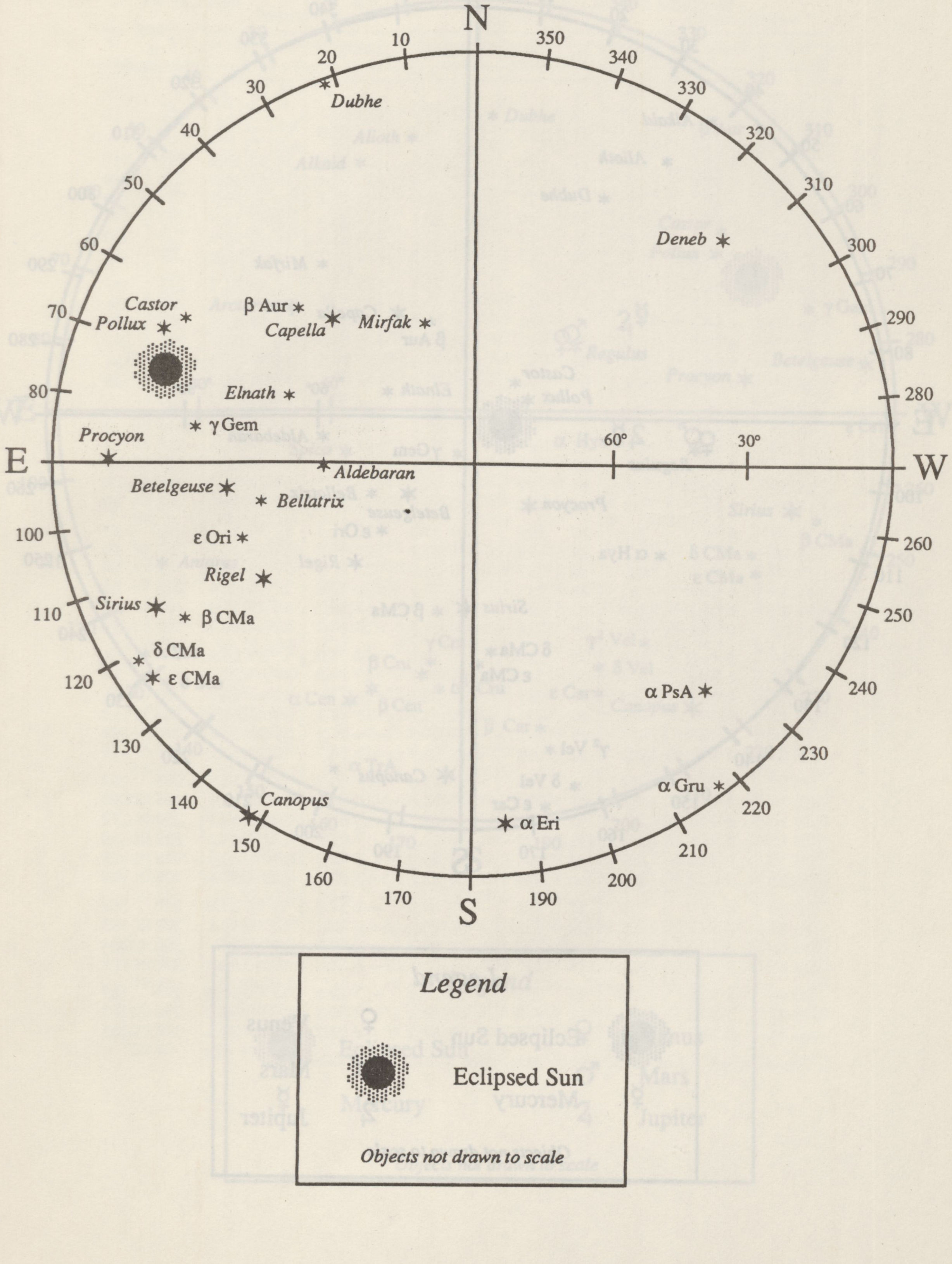


Figure 4a, b: Frequency of clear, scattered, broken, and overcast cloud cover at various locations along the eclipse track in Hawaii (a) and Mexico (b). Data were subjectively extracted from satellite imagery during July 1988. While too short a period for reliable climatological statistics, the graphs do show the relative merits of the various sites.

Sky Diagram for Kailua Kona, Hawaii
11 July 1991, 17h 30m UT

Diagram centered on zenith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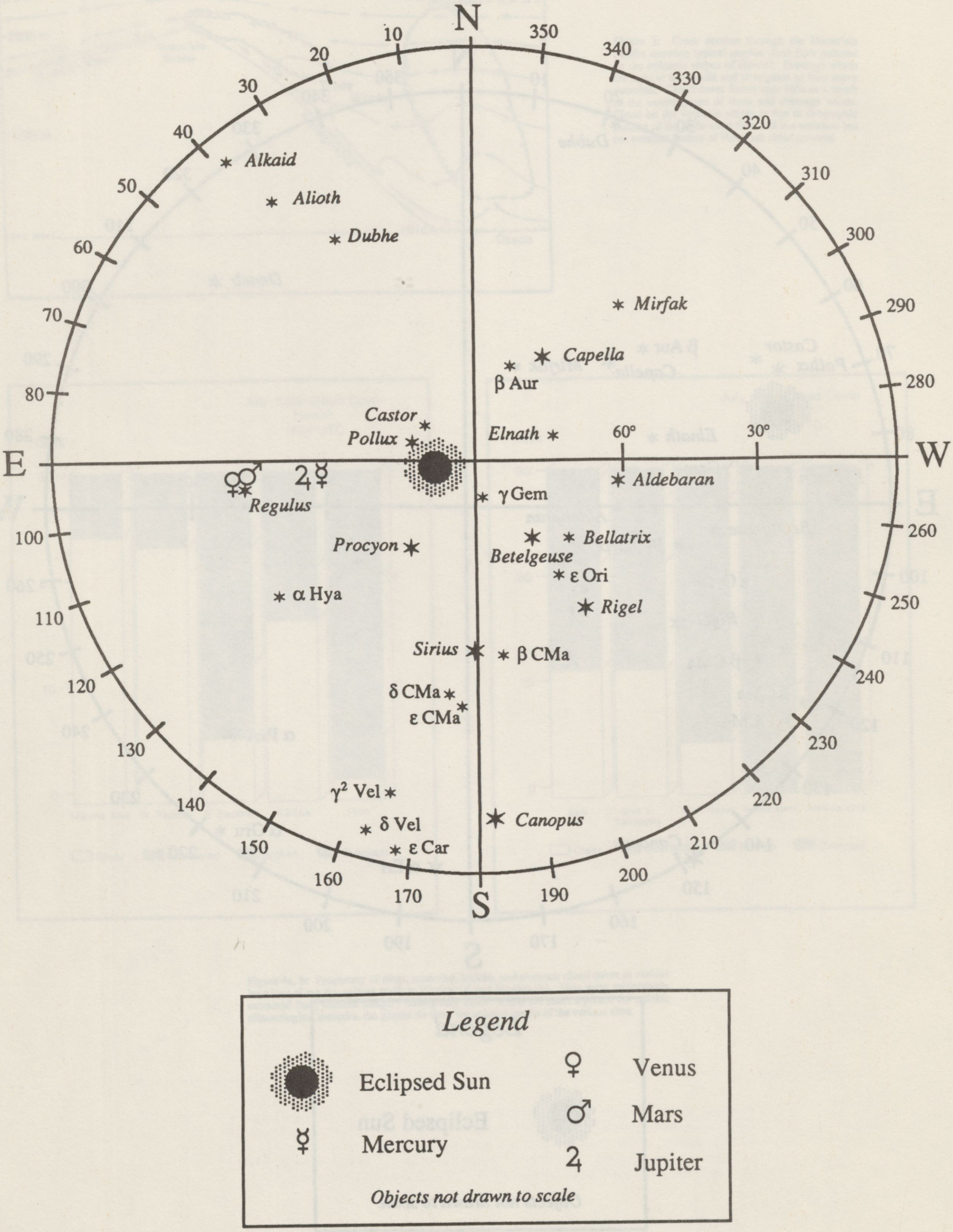
Mirfak
Elnath
γ Gem
Procyon
Aldebaran
Betelgeuse
Bellatrix
ε Ori
Rigel
Sirius
β CMa
δ CMa
ε CMa
α PsA
α Gru
Canopus
α Eri
Legend
Eclipsed Sun
Objects not drawn to scale

Sky Diagram for La Paz, Baja California, Mexico
11 July 1991, 18h 51m UT
Diagram centered on zenith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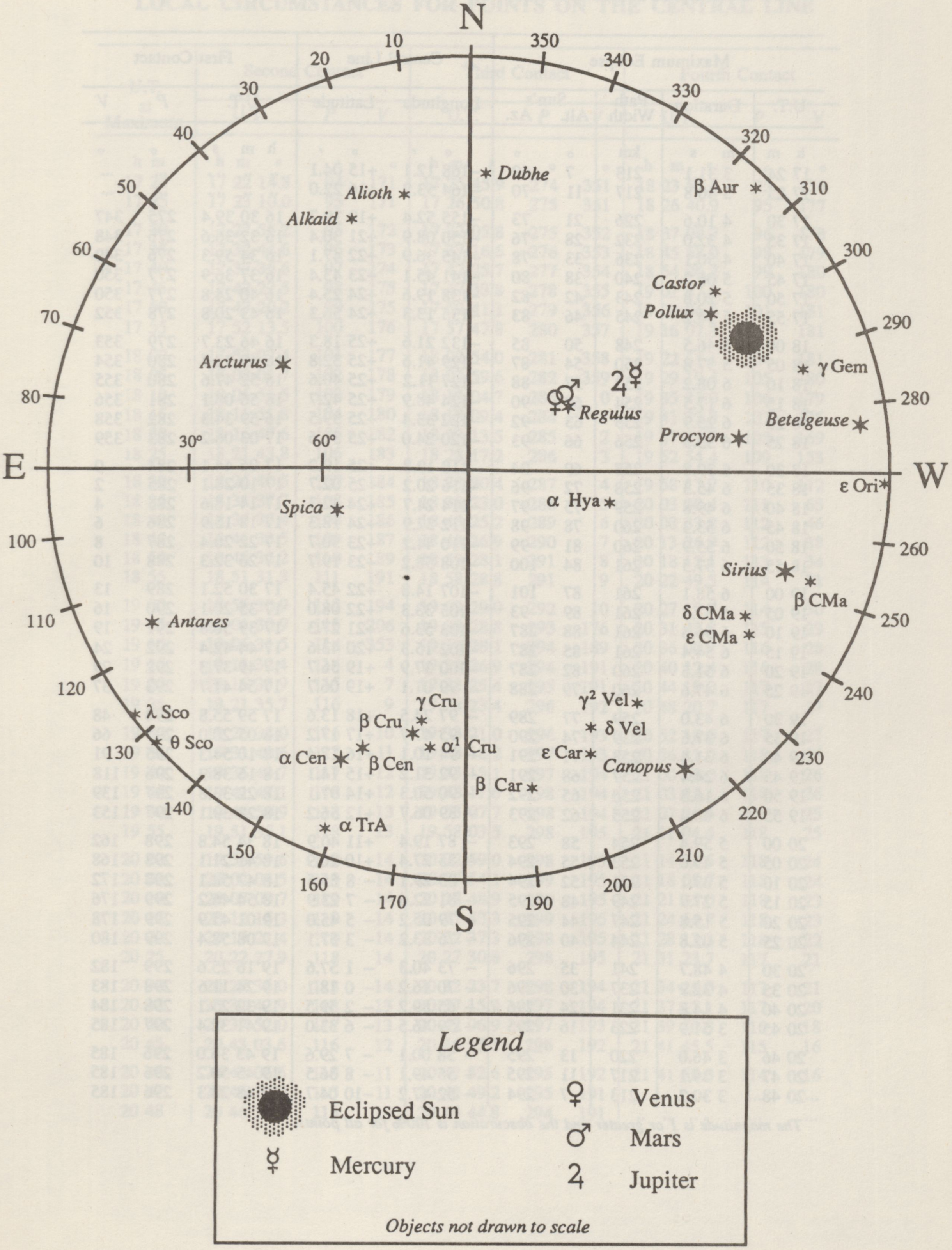
Alioth
Dubhe
Mirfak
Capella
β Aur
Castor
Pollux
Elnath
Aldebaran
♀♂
♃☿
Regulus
γ Gem
Procyon
Betelgeuse
Bellatrix
ε Ori
Rigel
α Hya
Sirius
β CMa
δ CMa
ε CMa
γ² Vel
δ Vel
ε Car
Canopus
Legend
Eclipsed Sun
☿ Mercury
♀ Venus
♂ Mars
♃ Jupiter
Objects not drawn to scale

Sky Diagram for Brazil: 66° W, 3° S
11 July 1991, 20h 40m UT

Diagram centered on zenith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Alioth
Alkaid
β Aur
Castor
Pollux
γ Gem
Arcturus
Regulus
Procyon
Betelgeuse
ε Ori
α Hya
Spica
Sirius
β CMa
δ CMa
ε CMa
Antares
λ Sco
θ Sco
γ Cru
β Cru
α¹ Cru
α Cen
β Cen
γ² Vel
δ Vel
ε Car
Canopus
β Car
α TrA
Legend
Eclipsed Sun
Mercury
Venus
Mars
Jupiter
Objects not drawn to scale

LOCAL CIRCUMSTANCES FOR POINTS ON THE CENTRAL LINE

Maximum Eclipse					Central Line		First Contact		
U.T.	Duration	Path Width	Sun's Alt.	Sun's Az.	Longitude	Latitude	U.T.	*P*	*V*
h m	m s	km	°	°	° ′	° ′	h m s	°	°
17 24	3 31.1	213	7	69	−168 12.1	+15 04.1	.. ..	...	...
17 25	3 40.8	217	11	70	−164 53.2	+16 22.0	.. ..	...	...
17 30	4 10.6	226	21	73	−155 52.4	+19 39.7	16 30 39.4	275	347
17 35	4 32.0	232	28	76	−150 08.9	+21 30.4	16 32 36.6	276	348
17 40	4 50.1	236	33	78	−145 36.9	+22 47.1	16 34 59.3	276	349
17 45	5 06.2	240	38	80	−141 45.1	+23 43.4	16 37 36.9	277	350
17 50	5 20.8	243	42	82	−138 19.6	+24 25.4	16 40 24.8	277	350
17 55	5 34.2	245	46	83	−135 13.3	+24 56.3	16 43 20.8	278	352
18 00	5 46.5	248	50	85	−132 21.6	+25 18.3	16 46 23.7	279	353
18 05	5 57.8	250	54	87	−129 41.6	+25 32.8	16 49 32.7	280	354
18 10	6 08.2	252	57	88	−127 11.2	+25 40.6	16 52 47.6	280	355
18 15	6 17.5	254	60	90	−124 48.9	+25 42.7	16 56 08.1	281	356
18 20	6 25.9	255	63	92	−122 33.4	+25 39.5	16 59 34.3	282	358
18 25	6 33.3	256	66	93	−120 24.0	+25 31.6	17 03 06.2	283	359
18 30	6 39.8	258	69	94	−118 19.8	+25 19.2	17 06 44.1	284	0
18 35	6 45.3	258	72	96	−116 20.2	+25 02.7	17 10 28.1	285	2
18 40	6 49.8	259	75	97	−114 24.7	+24 42.3	17 14 18.6	285	4
18 45	6 53.3	260	78	98	−112 32.9	+24 18.3	17 18 15.9	286	6
18 50	6 55.9	260	81	99	−110 44.2	+23 50.7	17 22 20.4	287	8
18 55	6 57.5	261	84	100	−108 58.2	+23 19.7	17 26 32.3	288	10
19 00	6 58.1	261	87	101	−107 14.8	+22 45.4	17 30 52.1	289	13
19 05	6 57.8	261	89	93	−105 33.3	+22 08.0	17 35 20.1	290	16
19 10	6 56.6	261	88	287	−103 53.6	+21 27.3	17 39 56.8	291	19
19 15	6 54.4	261	85	287	−102 15.3	+20 43.6	17 44 42.4	292	24
19 20	6 51.5	260	82	287	−100 37.9	+19 56.7	17 49 37.3	292	29
19 25	6 47.6	260	79	288	− 99 01.1	+19 06.7	17 54 41.7	293	37
19 30	6 43.0	259	77	289	− 97 24.5	+18 13.6	17 59 55.8	294	48
19 35	6 37.6	259	74	290	− 95 47.7	+17 17.2	18 05 20.0	295	66
19 40	6 31.4	258	71	291	− 94 10.1	+16 17.4	18 10 54.3	295	91
19 45	6 24.4	257	68	291	− 92 31.2	+15 14.1	18 16 38.9	296	118
19 50	6 16.8	256	65	292	− 90 50.3	+14 07.1	18 22 33.8	297	139
19 55	6 08.4	255	62	293	− 89 06.7	+12 56.2	18 28 39.1	297	153
20 00	5 59.4	254	58	293	− 87 19.4	+11 40.9	18 34 54.8	298	162
20 05	5 49.6	253	55	294	− 85 27.4	+10 20.9	18 41 21.1	298	168
20 10	5 39.1	251	52	294	− 83 29.1	− 8 55.5	18 47 58.1	298	172
20 15	5 27.9	249	48	295	− 81 22.6	− 7 23.9	18 54 46.2	299	176
20 20	5 15.8	247	44	295	− 79 05.2	− 5 45.0	19 01 45.9	299	178
20 25	5 02.8	244	40	296	− 76 33.2	− 3 57.1	19 08 58.4	299	180
20 30	4 48.7	241	35	296	− 73 40.3	− 1 57.6	19 16 25.6	299	182
20 35	4 32.9	237	30	296	− 70 16.2	− 0 18.1	19 24 11.6	298	183
20 40	4 14.8	231	24	296	− 65 59.2	− 2 59.5	19 32 25.1	298	184
20 45	3 51.9	223	16	295	− 59 46.5	− 6 33.0	19 41 32.4	297	185
20 46	3 46.0	220	13	295	− 58 00.1	− 7 29.6	19 43 36.0	296	185
20 47	3 39.1	217	11	295	− 55 49.1	− 8 36.5	19 45 50.2	296	185
20 48	3 30.2	213	7	294	− 52 47.2	−10 04.7	19 48 26.3	296	185

The magnitude is 1 or greater and the obscuration is 100% for all points.

LOCAL CIRCUMSTANCES FOR POINTS ON THE CENTRAL LINE

U.T. at Maximum	Second Contact			Third Contact			Fourth Contact		
	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*
h m	h m s	°	°	h m s	°	°	h m s	°	°
17 24	17 22 14.8	94	171	17 25 45.9	274	351	18 23 52.5	95	176
17 25	17 23 10.0	95	171	17 26 50.8	275	351	18 26 40.9	95	177
17 30	17 27 55.2	95	172	17 32 05.8	275	352	18 37 08.7	96	178
17 35	17 32 44.6	96	173	17 37 16.6	276	353	18 45 58.0	98	179
17 40	17 37 35.6	97	174	17 42 25.7	277	354	18 54 06.2	99	180
17 45	17 42 27.5	98	175	17 47 33.8	278	355	19 01 47.2	100	180
17 50	17 47 20.2	99	175	17 52 41.1	279	356	19 09 06.6	101	181
17 55	17 52 13.5	100	176	17 57 47.8	280	357	19 16 07.3	102	181
18 00	17 57 07.4	101	177	18 02 54.0	281	358	19 22 51.1	104	181
18 05	18 02 01.7	102	178	18 07 59.6	282	359	19 29 19.4	105	180
18 10	18 06 56.5	103	179	18 13 04.7	283	0	19 35 33.0	106	179
18 15	18 11 51.8	104	180	18 18 09.4	284	1	19 41 32.8	107	175
18 20	18 16 47.6	105	182	18 23 13.5	285	2	19 47 19.7	108	169
18 25	18 21 43.8	106	183	18 28 17.2	286	3	19 52 54.4	109	153
18 30	18 26 40.5	107	184	18 33 20.4	287	4	19 58 17.7	110	112
18 35	18 31 37.7	108	185	18 38 23.0	288	5	20 03 30.4	111	65
18 40	18 36 35.4	108	186	18 43 25.2	289	6	20 08 33.2	112	46
18 45	18 41 33.5	109	187	18 48 26.9	290	7	20 13 26.9	112	38
18 50	18 46 32.2	110	189	18 53 28.1	291	8	20 18 12.1	113	34
18 55	18 51 31.3	111	191	18 58 28.8	291	9	20 22 49.5	114	31
19 00	18 56 30.9	112	194	19 03 29.0	292	10	20 27 19.7	114	30
19 05	19 01 30.9	113	206	19 08 28.8	293	176	20 31 43.2	115	29
19 10	19 06 31.5	114	353	19 13 28.1	294	189	20 36 00.7	116	28
19 15	19 11 32.4	114	4	19 18 26.9	294	191	20 40 12.4	116	28
19 20	19 16 33.9	115	7	19 23 25.4	295	191	20 44 19.0	117	27
19 25	19 21 35.7	116	9	19 28 23.4	296	192	20 48 20.7	117	27
19 30	19 26 38.0	116	10	19 33 21.0	296	193	20 52 18.0	117	27
19 35	19 31 40.6	117	11	19 38 18.2	297	193	20 56 11.0	118	26
19 40	19 36 43.7	117	12	19 43 15.1	297	194	21 00 00.0	118	26
19 45	19 41 47.1	118	12	19 48 11.6	298	194	21 03 45.1	118	26
19 50	19 46 50.9	118	13	19 53 07.7	298	194	21 07 26.6	118	25
19 55	19 51 55.1	118	13	19 58 03.5	298	195	21 11 04.4	118	25
20 00	19 56 59.6	118	14	20 02 59.0	298	195	21 14 38.5	118	24
20 05	20 02 04.5	119	14	20 07 54.1	299	195	21 18 08.7	118	24
20 10	20 07 09.7	119	14	20 12 48.9	299	195	21 21 35.0	118	23
20 15	20 12 15.3	119	14	20 17 43.3	299	195	21 24 56.7	118	23
20 20	20 17 21.4	119	14	20 22 37.3	298	195	21 28 13.3	118	22
20 25	20 22 27.9	118	14	20 27 30.8	298	195	21 31 23.7	117	21
20 30	20 27 35.0	118	14	20 32 23.7	298	194	21 34 26.0	117	21
20 35	20 32 42.9	118	13	20 37 15.9	297	194	21 37 17.1	117	20
20 40	20 37 52.0	117	13	20 42 06.9	297	193	21 39 50.3	116	18
20 45	20 43 03.6	116	12	20 46 55.5	296	192	21 41 45.5	115	16
20 46	20 44 06.6	115	11	20 47 52.6	295	192	21 41 58.3	114	16
20 47	20 45 10.0	115	11	20 48 49.2	295	191	.. ..	...	...
20 48	20 46 14.5	115	10	20 49 44.8	294	191	.. ..	...	...

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		Name of Location	Duration of Totality	Maximum Eclipse					
Latitude	Longitude			Path Width	U.T.	Obscur.	Mag.	Sun's Alt.	Sun's Az.
° ′	° ′	***Hawaiian Islands (USA)***	m s	km	h m s	%		°	°
+19 30.0	−155 55.0	Captain Cook, Hawaii	4 08.1	226	17 29 53.8	100.0	1.030	21	73
+19 29.0	−155 09.0	Glenwood, Hawaii	3 52.9	226	17 30 20.7	100.0	1.021	22	73
+20 42.4	−156 15.4	Haleakala, Maui (Mees Solar Obs.)			17 30 15.4	99.8	0.996	21	73
+20 45.0	−156 00.0	Hana, Maui			17 30 28.6	99.9	0.997	21	73
+20 14.0	−155 50.0	Hawi, Hawaii	3 35.5	227	17 30 18.4	100.0	1.017	21	73
+19 42.0	−155 04.0	Hilo, Hawaii	4 07.4	227	17 30 30.1	100.0	1.027	22	73
+19 37.0	−155 57.0	Holualoa, Hawaii	4 10.3	226	17 29 56.0	100.0	1.034	21	73
+19 25.0	−155 55.0	Honaunau, Hawaii	4 04.6	226	17 29 51.4	100.0	1.027	21	73
+20 04.0	−155 27.0	Honokaa, Hawaii	4 04.9	227	17 30 27.0	100.0	1.026	21	73
+19 41.0	−155 58.0	Honokohau, Hawaii	4 10.0	226	17 29 57.4	100.0	1.033	21	73
+21 19.0	−157 50.0	Honolulu, Oahu			17 29 48.1	96.3	0.960	20	73
+19 51.0	−155 06.0	Honomu, Hawaii	4 12.8	227	17 30 33.3	100.0	1.032	22	73
+19 12.0	−155 55.0	Hoopuloa, Hawaii	3 47.9	226	17 29 45.1	100.0	1.020	21	73
+18 58.0	−155 37.0	Kaalualu, Hawaii	2 53.5	226	17 29 49.1	100.0	1.010	21	73
+20 56.0	−156 29.0	Kahului, Maui			17 30 18.1	99.1	0.987	21	73
+21 24.0	−157 45.0	Kailua, Oahu			17 29 53.3	96.1	0.959	20	73
+19 43.0	−155 59.0	Kailua Kona, Hawaii	4 09.4	226	17 29 57.8	100.0	1.031	21	73
+19 22.0	−154 58.0	Kaimu, Hawaii	3 30.9	226	17 30 24.1	100.0	1.015	22	73
+19 43.0	−155 59.0	Kalaoa, Hawaii	4 09.4	226	17 29 57.8	100.0	1.031	21	73
+21 25.0	−157 48.0	Kaneohe, Oahu			17 29 52.3	96.0	0.958	20	73
+19 54.0	−155 53.0	Kapalaoa, Hawaii	4 04.5	226	17 30 06.7	100.0	1.027	21	73
+21 08.0	−157 02.0	Kaunakakai, Molokai			17 30 06.6	98.0	0.975	20	73
+20 37.0	−156 08.0	Kaupo, Maui	1 10.9	227	17 30 19.9	100.0	1.001	21	73
+20 02.0	−155 50.0	Kawaihae, Hawaii	3 57.0	226	17 30 12.4	100.0	1.023	21	73
+19 36.0	−155 02.0	Keaau, Hawaii	4 00.2	227	17 30 28.4	100.0	1.023	22	73
+19 31.0	−155 56.0	Kealakekua, Hawaii	4 08.7	226	17 29 53.7	100.0	1.030	21	73
+20 36.0	−156 25.0	Keoneoio, Maui			17 30 09.8	99.9	0.998	21	73
+20 39.0	−156 04.0	Kipahulu, Maui	1 02.4	227	17 30 23.2	100.0	1.001	21	73
+20 41.0	−156 02.0	Koali, Maui	0 38.0	227	17 30 25.4	100.0	1.000	21	73
+19 35.0	−155 04.0	Kurtistown, Hawaii	3 59.7	227	17 30 26.7	100.0	1.023	22	73
+20 53.0	−156 40.0	Lahaina, Maui			17 30 10.5	99.1	0.987	21	73
+20 50.0	−156 56.0	Lanai City, Lanai			17 30 00.3	99.0	0.986	20	73
+20 00.0	−155 15.0	Laupahoehoe, Hawaii	4 11.2	227	17 30 32.2	100.0	1.031	22	73
+21 59.0	−159 23.0	Lihue, Kauai			17 29 27.3	91.7	0.922	18	73
+19 47.0	−156 02.0	Makalewena, Hawaii	4 06.8	226	17 29 58.1	100.0	1.029	21	73
+19 49.6	−155 28.3	Mauna Kea (Mauna Kea Obs.)	4 12.0	226	17 30 14.7	100.0	1.033	21	73
+19 32.0	−155 03.0	Mountain View, Hawaii	3 54.8	227	17 30 25.8	100.0	1.022	22	73
+19 04.0	−155 36.0	Naalehu, Hawaii	3 14.0	226	17 29 52.5	100.0	1.013	21	73
+19 12.0	−155 28.0	Pahala, Hawaii	3 29.6	226	17 30 01.0	100.0	1.015	21	73
+19 29.0	−154 56.0	Pahoa, Hawaii	3 45.6	227	17 30 28.7	100.0	1.019	22	73
+19 48.0	−155 50.0	Puuanahulu, Hawaii	4 09.2	226	17 30 05.5	100.0	1.030	21	73
+20 42.0	−156 01.0	Puuiki, Maui	0 14.2	227	17 30 26.4	100.0	1.000	21	73
+19 25.0	−155 15.0	Volcano, Hawaii	3 49.1	226	17 30 15.1	100.0	1.020	21	73
+21 30.0	−158 00.0	Wahiawa, Oahu			17 29 49.2	95.4	0.953	19	73
+21 35.0	−158 08.0	Waialua, Oahu			17 29 48.0	94.9	0.949	19	73
+19 51.0	−155 40.0	Waikii, Hawaii	4 10.0	226	17 30 12.8	100.0	1.031	21	73
+20 54.0	−156 30.0	Wailuku, Maui			17 30 16.5	99.2	0.988	21	73
+20 02.0	−155 20.0	Waimea, Hawaii	4 08.9	227	17 30 30.2	100.0	1.029	22	73
		Baja California, Mexico							
+23 28.0	−109 25.0	Cabo Pulmo	6 57.1	261	18 53 43.6	100.0	1.040	83	100
+25 16.0	−111 47.0	Ejido Insurgentes	2 15.7	260	18 46 13.6	100.0	1.002	79	104
+24 35.0	−111 29.0	El Medano	6 10.5	260	18 47 30.0	100.0	1.022	80	102
+31 53.0	−116 35.0	Ensenada			18 31 47.9	77.6	0.810	70	114
+23 59.0	−109 50.0	Ensenada de los Muertos	6 33.9	260	18 52 11.6	100.0	1.027	82	102
+24 10.0	−110 17.0	La Paz	6 26.6	260	18 50 53.3	100.0	1.026	82	102
+25 01.0	−110 52.0	Los Burros	2 32.8	260	18 48 42.7	100.0	1.003	80	106
+25 05.0	−110 52.0	Los Dolores	1 14.8	260	18 48 39.6	100.0	1.001	80	106
+23 47.0	−110 39.0	Los Inocentes	6 55.9	260	18 50 16.5	100.0	1.039	81	99
+32 38.0	−115 27.0	Mexicali			18 33 55.9	73.7	0.779	71	118
+23 20.0	−109 45.0	Miraflores	6 50.1	261	18 52 59.4	100.0	1.033	83	98
+24 29.0	−111 50.0	Puerto Cortes	6 35.8	260	18 46 41.3	100.0	1.029	79	100
+23 47.0	−110 06.0	San Antonio	6 54.3	260	18 51 41.2	100.0	1.037	82	100
+23 04.0	−109 41.0	San Jose del Cabo	6 25.5	261	18 53 24.3	100.0	1.025	83	96
+22 53.0	−109 55.0	San Lucas	5 37.4	261	18 52 57.9	100.0	1.016	83	94
+23 57.0	−110 16.0	San Pedro	6 48.0	260	18 51 07.0	100.0	1.033	82	101

Assumed to be sea level, except observatories.

Names and spelling are not authoritative, nor do they imply any official recognition of status.

No correction for elevation, limb or refraction included.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		First Contact			Second Contact			Third Contact			Fourth Contact		
Latitude	Longitude	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*
° ′	° ′	h m s	°	°	h m s	°	°	h m s	°	°	h m s	°	°
+19 30.0	−155 55.0	16 30 34.5	275	347	17 27 50.2	103	180	17 31 58.3	268	345	18 37 01.4	96	178
+19 29.0	−155 09.0	16 30 38.3	276	348	17 28 24.7	119	195	17 32 17.6	253	330	18 37 59.3	96	178
+20 42.4	−156 15.4	16 31 08.1	273	344							18 37 01.6	99	179
+20 45.0	−156 00.0	16 31 13.3	273	344							18 37 25.0	98	179
+20 14.0	−155 50.0	16 30 56.9	274	345	17 28 31.1	65	141	17 32 06.7	306	22	18 37 25.7	97	178
+19 42.0	−155 04.0	16 30 44.9	275	348	17 28 26.9	108	185	17 32 34.3	263	340	18 38 11.3	96	178
+19 37.0	−155 57.0	16 30 37.7	275	347	17 27 51.3	96	173	17 32 01.7	274	351	18 37 01.9	96	178
+19 25.0	−155 55.0	16 30 32.2	275	347	17 27 49.5	108	184	17 31 54.2	263	340	18 36 59.3	96	178
+20 04.0	−155 27.0	16 30 53.5	274	346	17 28 25.0	82	158	17 32 30.0	289	6	18 37 50.9	97	178
+19 41.0	−155 58.0	16 30 39.6	275	347	17 27 52.9	93	169	17 32 02.9	278	355	18 37 02.3	97	178
+21 19.0	−157 50.0	16 31 32.2	271	341							18 35 23.3	100	179
+19 51.0	−155 06.0	16 30 49.0	275	347	17 28 27.4	100	176	17 32 40.2	272	348	18 38 12.5	96	178
+19 12.0	−155 55.0	16 30 26.3	276	348	17 27 51.6	120	197	17 31 39.6	251	328	18 36 53.7	96	177
+18 58.0	−155 37.0	16 30 21.8	276	349	17 28 22.6	142	219	17 31 16.2	229	307	18 37 10.0	95	177
+20 56.0	−156 29.0	16 31 18.4	272	343							18 36 52.9	99	179
+21 24.0	−157 45.0	16 31 35.3	271	340							18 35 30.8	100	179
+19 43.0	−155 59.0	16 30 40.5	275	347	17 27 53.6	91	167	17 32 03.0	280	357	18 37 01.9	97	178
+19 22.0	−154 58.0	16 30 36.4	276	349	17 28 39.1	129	206	17 32 10.1	242	319	18 38 10.4	96	178
+19 43.0	−155 59.0	16 30 40.5	275	347	17 27 53.6	91	167	17 32 03.0	280	357	18 37 01.9	97	178
+21 25.0	−157 48.0	16 31 36.0	271	340							18 35 27.6	101	179
+19 54.0	−155 53.0	16 30 46.4	274	346	17 28 04.9	83	159	17 32 09.4	288	5	18 37 13.9	97	178
+21 08.0	−157 02.0	16 31 24.9	272	342							18 36 16.8	100	179
+20 37.0	−156 08.0	16 31 08.3	273	344	17 29 44.7	22	97	17 30 55.6	349	65	18 37 12.0	98	178
+20 02.0	−155 50.0	16 30 50.6	274	346	17 28 14.4	76	152	17 32 11.4	295	11	18 37 20.9	97	178
+19 36.0	−155 02.0	16 30 42.3	276	348	17 28 28.8	114	191	17 32 29.0	257	334	18 38 11.4	96	178
+19 31.0	−155 56.0	16 30 34.9	275	347	17 27 49.8	102	179	17 31 58.5	269	346	18 37 00.6	96	178
+20 36.0	−156 25.0	16 31 07.0	273	344							18 36 50.5	98	178
+20 39.0	−156 04.0	16 31 09.6	273	344	17 29 52.2	20	95	17 30 54.7	351	67	18 37 17.7	98	178
+20 41.0	−156 02.0	16 31 10.9	273	344	17 30 06.6	14	90	17 30 44.6	357	72	18 37 21.0	98	178
+19 35.0	−155 04.0	16 30 41.6	276	348	17 28 27.3	115	191	17 32 27.0	257	334	18 38 08.3	96	178
+20 53.0	−156 40.0	16 31 16.3	272	343							18 36 38.3	99	179
+20 50.0	−156 56.0	16 31 14.1	272	343							18 36 17.7	99	179
+20 00.0	−155 15.0	16 30 52.5	275	347	17 28 27.1	89	165	17 32 38.4	282	359	18 38 04.7	97	178
+21 59.0	−159 23.0	16 32 04.4	269	337							18 33 49.5	102	180
+19 47.0	−156 02.0	16 30 42.2	275	346	17 27 55.1	86	162	17 32 02.0	285	1	18 36 59.8	97	178
+19 49.6	−155 28.3	16 30 42.1	275	347	17 28 09.2	94	170	17 32 21.2	277	354	18 37 39.0	97	178
+19 32.0	−155 03.0	16 30 40.4	276	348	17 28 28.9	118	195	17 32 23.8	254	331	18 38 08.3	96	178
+19 04.0	−155 36.0	16 30 24.5	276	349	17 28 15.9	135	212	17 31 29.9	236	313	18 37 13.9	95	177
+19 12.0	−155 28.0	16 30 28.7	276	348	17 28 16.6	129	206	17 31 46.3	242	319	18 37 27.6	95	177
+19 29.0	−154 56.0	16 30 39.8	276	348	17 28 36.4	123	200	17 32 22.0	248	326	18 38 16.1	96	178
+19 48.0	−155 50.0	16 30 43.6	275	347	17 28 01.4	89	165	17 32 10.6	282	359	18 37 15.2	97	178
+20 42.0	−156 01.0	16 31 11.5	273	344	17 30 19.6	9	84	17 30 33.8	2	78	18 37 22.6	98	178
+19 25.0	−155 15.0	16 30 35.9	276	348	17 28 21.0	120	197	17 32 10.2	251	328	18 37 49.9	96	178
+21 30.0	−158 00.0	16 31 39.6	270	340							18 35 15.2	101	179
+21 35.0	−158 08.0	16 31 43.2	270	340							18 35 07.4	101	179
+19 51.0	−155 40.0	16 30 45.9	275	347	17 28 08.3	89	166	17 32 18.3	282	358	18 37 29.1	97	178
+20 54.0	−156 30.0	16 31 17.2	272	343							18 36 50.9	99	179
+20 02.0	−155 20.0	16 30 53.1	275	346	17 28 26.2	86	162	17 32 35.1	285	2	18 37 59.0	97	178
+23 28.0	−109 25.0	17 25 27.4	288	10	18 50 15.1	111	190	18 57 12.3	291	8	20 21 39.6	114	32
+25 16.0	−111 47.0	17 19 49.6	284	2	18 45 05.8	39	111	18 47 21.6	0	72	20 13 55.7	115	44
+24 35.0	−111 29.0	17 20 32.6	286	5	18 44 24.8	84	159	18 50 35.4	316	30	20 15 31.8	114	39
+31 53.0	−116 35.0	17 13 02.1	272	338							19 54 01.7	122	119
+23 59.0	−109 50.0	17 24 21.1	287	7	18 48 54.7	92	168	18 55 28.7	309	24	20 20 01.6	114	35
+24 10.0	−110 17.0	17 23 17.2	287	7	18 47 40.0	89	165	18 54 06.7	312	26	20 18 46.8	114	36
+25 01.0	−110 52.0	17 21 51.0	285	3	18 47 26.4	42	114	18 49 59.2	358	69	20 16 18.5	115	42
+25 05.0	−110 52.0	17 21 50.6	285	3	18 48 02.2	31	102	18 49 17.0	10	80	20 16 12.9	115	42
+23 47.0	−110 39.0	17 22 33.0	287	8	18 46 48.7	112	191	18 53 44.6	289	6	20 18 28.8	113	33
+32 38.0	−115 27.0	17 15 39.7	270	335							19 55 07.9	124	115
+23 20.0	−109 45.0	17 24 43.9	288	10	18 49 34.4	122	202	18 56 24.5	280	359	20 21 06.2	113	31
+24 29.0	−111 50.0	17 19 47.4	286	5	18 43 23.5	93	169	18 49 59.3	307	22	20 14 52.1	113	38
+23 47.0	−110 06.0	17 23 47.7	287	8	18 48 14.1	105	183	18 55 08.5	296	12	20 19 42.8	114	33
+23 04.0	−109 41.0	17 24 58.6	289	11	18 50 11.6	134	216	18 56 37.2	268	350	20 21 36.7	113	29
+22 53.0	−109 55.0	17 24 30.3	289	12	18 50 09.3	147	231	18 55 46.7	255	338	20 21 19.7	112	28
+23 57.0	−110 16.0	17 23 22.5	287	7	18 47 43.0	99	177	18 54 31.1	302	17	20 19 06.9	114	34

Dot leaders indicate the phenomenon occurs below the horizon. Blanks indicate the phenomenon does not occur for the location.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		Name of Location	Duration of Totality	Maximum Eclipse					
Latitude	Longitude			Path Width	U.T.	Obscur.	Mag.	Sun's Alt.	Sun's Az.
° ′	° ′	***Baja California (cont.)***	m s	km	h m s	%		°	°
+24 35.0	−111 30.0	Santa Rita	6 11.2	260	18 47 27.4	100.0	1.023	80	102
+23 32.0	−109 47.0	Santiago	6 56.7	261	18 52 43.4	100.0	1.039	83	99
+32 29.0	−117 10.0	Tijuana			18 30 25.8	75.3	0.792	69	114
+23 28.0	−110 14.0	Todos Santos	6 49.2	260	18 51 37.3	100.0	1.033	82	98
+25 02.0	−111 40.0	Villa Constitucion	4 20.1	260	18 46 41.6	100.0	1.009	79	103
		Mexico (mainland)							
+20 02.0	−100 44.0	Acambaro	6 51.5	260	19 19 38.3	100.0	1.039	82	287
+16 51.0	− 99 56.0	Acapulco			19 26 00.7	96.1	0.957	79	300
+21 51.0	−102 18.0	Aguascalientes	3 42.9	261	19 13 27.1	100.0	1.006	86	274
+20 34.0	−104 03.0	Ameca	4 42.0	261	19 10 42.1	100.0	1.011	87	306
+18 55.0	− 98 26.0	Atlixco	6 44.3	260	19 26 39.0	100.0	1.037	78	288
+30 59.0	−110 20.0	Cananea			18 45 40.3	76.5	0.801	77	132
+20 32.0	−100 48.0	Celaya	6 20.3	260	19 18 48.2	100.0	1.025	83	284
+28 40.0	−106 06.0	Chihuahua			18 56 56.6	81.2	0.838	83	155
+16 32.0	− 95 10.0	Ciudad Ixtepec	6 20.6	258	19 37 29.8	100.0	1.029	72	291
+16 15.0	− 92 08.0	Comitan de Dominguez	2 44.6	258	19 44 14.8	100.0	1.004	68	289
+18 53.0	− 96 55.0	Cordoba	4 51.4	260	19 30 09.7	100.0	1.013	76	286
+18 57.0	− 99 13.0	Cuernavaca	6 40.2	260	19 24 45.9	100.0	1.032	80	289
+24 01.0	−104 40.0	Durango			19 05 05.1	97.5	0.970	88	187
+20 40.0	−103 20.0	Guadalajara	6 18.3	261	19 12 23.5	100.0	1.023	87	295
+29 15.0	−110 59.0	Hermosillo			18 45 20.9	84.5	0.864	78	123
+19 10.0	− 96 58.0	Huatusco de Chincuellar	3 15.4	260	19 29 38.3	100.0	1.005	77	285
+15 08.0	− 92 28.0	Huixtla	6 23.7	257	19 45 15.8	100.0	1.038	68	291
+18 21.0	− 99 31.0	Iguala	4 24.3	260	19 24 53.8	100.0	1.009	80	293
+20 40.0	−101 21.0	Irapuato	6 36.0	261	19 17 17.7	100.0	1.029	84	284
+16 26.0	− 95 02.0	Juchitan	6 18.6	258	19 37 56.2	100.0	1.029	72	291
+31 03.2	−110 23.0	La Mariquita Mtn. (Cananea Obs.)			18 45 30.2	76.3	0.799	77	132
+21 08.0	−101 42.0	Leon	5 55.7	261	19 15 49.9	100.0	1.020	84	281
+23 11.0	−106 25.0	Mazatlan	5 41.5	261	19 01 39.6	100.0	1.017	88	116
+20 59.0	− 89 39.0	Merida			19 41 49.3	79.6	0.826	67	277
+19 25.0	− 99 10.0	Mexico City	6 42.0	260	19 24 13.6	100.0	1.034	80	287
+25 40.0	−100 20.0	Monterrey			19 13 14.4	84.2	0.861	83	241
+19 41.0	−101 11.0	Morelia	6 18.1	260	19 19 01.0	100.0	1.024	83	291
+17 05.0	− 96 43.0	Oaxaca de Juarez	5 36.4	259	19 33 14.8	100.0	1.018	75	292
+18 51.0	− 97 08.0	Orizaba	5 29.4	260	19 29 43.4	100.0	1.017	77	286
+20 07.0	− 98 45.0	Pachuca	3 32.6	260	19 24 13.0	100.0	1.006	80	283
+19 03.0	− 98 10.0	Puebla	6 26.9	260	19 27 04.6	100.0	1.028	78	287
+20 38.0	−105 15.0	Puerto Vallarta			19 07 32.0	99.9	0.994	88	174
+20 35.0	−100 23.0	Queretaro	5 36.1	260	19 19 44.0	100.0	1.017	82	283
+20 34.0	−101 12.0	Salamanca	6 38.2	261	19 17 47.5	100.0	1.030	83	285
+16 11.0	− 95 12.0	Salina Cruz	5 33.3	258	19 37 56.8	100.0	1.018	72	292
+20 14.0	−100 52.0	Salvatierra	6 48.3	260	19 19 02.7	100.0	1.035	83	286
+22 10.0	−101 00.0	San Luis Potosi			19 16 09.8	98.3	0.977	84	271
+31 02.6	−115 27.8	San Pedro Martir (National Obs.)			18 34 26.0	80.5	0.833	71	114
+20 05.0	−102 42.0	Sauhayo	5 17.2	261	19 14 43.7	100.0	1.014	85	296
+22 18.0	− 97 52.0	Tampico			19 23 10.7	92.4	0.926	79	271
+14 54.0	− 92 15.0	Tapachula	6 20.7	257	19 46 03.1	100.0	1.035	67	292
+18 28.0	− 97 25.0	Tehuacan	6 36.8	260	19 29 38.2	100.0	1.033	77	288
+16 19.0	− 95 15.0	Tehuantepec	5 50.5	258	19 37 38.4	100.0	1.021	72	292
+21 30.0	−104 51.0	Tepic	6 42.0	261	19 07 32.0	100.0	1.029	89	345
+18 28.0	− 96 21.0	Tierra Blanca	5 12.9	259	19 32 02.0	100.0	1.015	75	287
+19 20.0	− 99 40.0	Toluca	6 47.7	260	19 23 09.6	100.0	1.037	80	289
+16 06.0	− 93 45.0	Tonala	6 29.1	258	19 41 10.1	100.0	1.038	70	291
+19 02.0	− 98 18.8	Tonantzintla (National Obs.)	6 35.2	260	19 26 46.3	100.0	1.031	78	287
+25 34.0	−103 25.0	Torreon			19 06 19.1	89.7	0.905	86	206
+20 05.0	− 98 23.0	Tulancingo	1 35.0	260	19 25 06.6	100.0	1.001	79	283
+21 55.0	−105 18.0	Tuxpan	6 56.2	261	19 05 54.0	100.0	1.037	90	100
+16 45.0	− 93 09.0	Tuxtla Gutierrez	3 56.6	258	19 41 25.9	100.0	1.008	70	289
+19 26.0	−102 04.0	Uruapan del Progreso	2 45.7	260	19 17 09.9	100.0	1.003	84	297
+19 11.0	− 96 10.0	Veracruz			19 31 23.3	99.4	0.989	75	284
+19 28.0	−100 21.0	Zitacuaro	6 37.8	260	19 21 20.2	100.0	1.030	82	290
		Guatemala							
+14 33.0	− 90 42.0	Antigua	5 49.3	257	19 49 37.1	100.0	1.025	65	291
+14 18.0	− 90 47.0	Escuintla	6 12.1	257	19 49 50.1	100.0	1.033	65	292
+14 38.0	− 90 32.0	Guatemala City	5 23.0	257	19 49 48.7	100.0	1.019	65	291
+14 04.0	− 90 23.0	Guazacapan	6 08.5	256	19 50 57.0	100.0	1.032	64	292

Assumed to be sea level, except observatories.

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No correction for elevation, limb or refraction included.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		First Contact			Second Contact			Third Contact			Fourth Contact		
Latitude	Longitude	U.T.	P	V	U.T.	P	V	U.T.	P	V	U.T.	P	V
° ′	° ′	h m s	°	°	h m s	°	°	h m s	°	°	h m s	°	°
+24 35.0	−111 30.0	17 20 30.4	286	5	18 44 21.9	84	159	18 50 33.2	316	30	20 15 29.5	114	39
+23 32.0	−109 47.0	17 24 35.5	288	9	18 49 15.1	113	192	18 56 11.8	289	6	20 20 45.5	113	32
+32 29.0	−117 10.0	17 12 32.6	270	336							19 51 55.5	123	126
+23 28.0	−110 14.0	17 23 34.9	288	9	18 48 12.8	122	202	18 55 02.0	280	358	20 19 50.5	113	31
+25 02.0	−111 40.0	17 20 05.7	285	3	18 44 31.6	59	132	18 48 51.8	341	53	20 14 30.5	114	42
+20 02.0	−100 44.0	17 49 16.6	292	29	19 16 12.1	113	6	19 23 03.6	297	193	20 44 00.4	117	27
+16 51.0	− 99 56.0	17 54 47.1	298	50							20 50 03.3	113	18
+21 51.0	−102 18.0	17 43 46.6	289	17	19 11 35.4	57	322	19 15 18.4	352	258	20 38 21.6	118	32
+20 34.0	−104 03.0	17 40 12.0	292	24	19 08 20.9	161	25	19 13 03.0	246	125	20 37 01.5	114	24
+18 55.0	− 98 26.0	17 56 27.5	293	40	19 23 16.3	111	5	19 30 00.6	301	198	20 49 36.4	117	27
+30 59.0	−110 20.0	17 24 21.5	274	339							20 07 47.8	125	81
+20 32.0	−100 48.0	17 48 40.4	291	25	19 15 37.7	93	349	19 21 58.0	317	217	20 43 06.4	117	29
+28 40.0	−106 06.0	17 32 48.1	278	346							20 19 42.3	125	61
+16 32.0	− 95 10.0	18 07 56.0	296	78	19 34 18.9	133	26	19 40 39.6	281	177	20 58 14.1	117	25
+16 15.0	− 92 08.0	18 16 22.9	294	120	19 42 52.1	53	311	19 45 36.8	2	261	21 02 41.2	120	29
+18 53.0	− 96 55.0	18 00 33.7	292	45	19 27 43.6	73	331	19 32 35.1	340	239	20 52 01.1	119	29
+18 57.0	− 99 13.0	17 54 19.9	294	38	19 21 25.3	127	19	19 28 05.6	284	179	20 48 16.2	117	26
+24 01.0	−104 40.0	17 36 39.7	286	7							20 30 29.6	119	38
+20 40.0	−103 20.0	17 41 57.7	292	23	19 09 14.1	139	17	19 15 32.4	269	158	20 38 16.5	115	26
+29 15.0	−110 59.0	17 22 11.8	277	347							20 09 33.5	122	72
+19 10.0	− 96 58.0	18 00 08.5	292	42	19 28 00.3	55	314	19 31 15.7	357	257	20 51 29.1	119	30
+15 08.0	− 92 28.0	18 16 55.6	296	119	19 42 03.3	120	15	19 48 27.0	295	191	21 03 58.3	118	25
+18 21.0	− 99 31.0	17 54 09.5	295	41	19 22 41.4	165	54	19 27 05.7	246	137	20 48 39.9	115	24
+20 40.0	−101 21.0	17 47 07.2	291	24	19 13 59.4	98	353	19 20 35.4	311	210	20 41 56.0	117	29
+16 26.0	− 95 02.0	18 08 24.9	296	80	19 34 46.3	133	27	19 41 04.9	281	176	20 58 34.6	117	25
+31 03.2	−110 23.0	17 24 16.0	273	339							20 07 34.8	125	81
+21 08.0	−101 42.0	17 45 50.4	291	22	19 12 51.8	84	342	19 18 47.5	325	226	20 40 34.6	117	30
+23 11.0	−106 25.0	17 32 41.6	288	11	18 58 48.8	77	148	19 04 30.3	327	25	20 28 24.6	116	33
+20 59.0	− 89 39.0	18 18 17.7	284	174							20 57 00.4	129	46
+19 25.0	− 99 10.0	17 54 00.3	293	34	19 20 52.1	106	0	19 27 34.2	305	203	20 47 37.8	117	28
+25 40.0	−100 20.0	17 47 04.9	282	355							20 34 50.4	125	49
+19 41.0	−101 11.0	17 48 24.3	293	30	19 15 51.6	139	27	19 22 09.7	271	164	20 43 44.6	116	25
+17 05.0	− 96 43.0	18 03 06.2	296	61	19 30 26.2	150	42	19 36 02.6	264	158	20 55 06.4	116	24
+18 51.0	− 97 08.0	18 00 00.8	293	44	19 26 58.2	81	339	19 32 27.7	331	230	20 51 44.7	119	29
+20 07.0	− 98 45.0	17 54 28.1	291	30	19 22 26.5	57	317	19 25 59.1	354	255	20 47 11.3	119	31
+19 03.0	− 98 10.0	17 57 02.3	293	39	19 23 50.7	99	354	19 30 17.6	313	211	20 49 49.5	118	28
+20 38.0	−105 15.0	17 37 05.7	293	23							20 34 30.4	113	23
+20 35.0	−100 23.0	17 49 43.8	291	25	19 16 55.7	80	338	19 22 31.8	330	230	20 43 44.6	118	30
+20 34.0	−101 12.0	17 47 35.6	291	25	19 14 28.1	100	355	19 21 06.3	310	208	20 42 21.3	117	29
+16 11.0	− 95 12.0	18 08 17.1	296	80	19 35 09.7	150	42	19 40 43.1	264	159	20 58 42.4	117	24
+20 14.0	−100 52.0	17 48 45.0	292	27	19 15 38.2	107	1	19 22 26.5	302	200	20 43 27.7	117	28
+22 10.0	−101 00.0	17 46 56.9	288	16							20 40 06.0	120	35
+31 02.6	−115 27.8	17 14 21.7	273	341							19 57 36.4	122	107
+20 05.0	−102 42.0	17 44 04.8	293	27	19 12 04.8	155	35	19 17 22.1	254	142	20 40 20.8	115	25
+22 18.0	− 97 52.0	17 55 08.0	287	14							20 44 47.1	123	39
+14 54.0	− 92 15.0	18 17 48.6	296	123	19 42 52.1	124	19	19 49 12.8	291	187	21 04 35.4	118	25
+18 28.0	− 97 25.0	17 59 39.2	293	46	19 26 19.3	106	1	19 32 56.1	306	203	20 51 55.0	118	27
+16 19.0	− 95 15.0	18 07 58.9	296	79	19 34 42.6	145	38	19 40 33.1	269	164	20 58 26.3	117	24
+21 30.0	−104 51.0	17 37 29.7	291	19	19 04 10.8	129	297	19 10 52.8	277	160	20 34 04.4	115	27
+18 28.0	− 96 21.0	18 02 31.2	293	51	19 29 25.2	78	335	19 34 38.1	335	234	20 53 31.5	119	29
+19 20.0	− 99 40.0	17 52 45.2	293	34	19 19 45.2	121	13	19 26 33.0	290	186	20 46 55.4	117	27
+16 06.0	− 93 45.0	18 12 15.8	295	97	19 37 54.9	114	9	19 44 24.0	300	197	21 00 51.2	118	26
+19 02.0	− 98 18.8	17 56 39.2	293	39	19 23 28.3	103	358	19 30 03.5	309	206	20 49 38.4	118	28
+25 34.0	−103 25.0	17 39 18.3	283	359							20 30 03.4	122	46
+20 05.0	− 98 23.0	17 55 28.6	291	31	19 24 19.0	39	300	19 25 54.0	12	273	20 47 49.3	119	31
+21 55.0	−105 18.0	17 36 06.1	290	17	19 02 25.8	118	226	19 09 22.0	288	172	20 32 33.5	115	28
+16 45.0	− 93 09.0	18 13 03.9	294	102	19 39 27.3	65	323	19 43 23.9	350	248	21 00 38.2	120	29
+19 26.0	−102 04.0	17 46 19.0	294	31	19 15 46.9	181	64	19 18 32.7	228	114	20 42 29.5	114	23
+19 11.0	− 96 10.0	18 02 16.7	292	45							20 52 37.6	120	31
+19 28.0	−100 21.0	17 50 48.6	293	32	19 18 00.9	130	21	19 24 38.8	281	175	20 45 32.7	116	26
+14 33.0	− 90 42.0	18 22 20.5	296	140	19 46 41.8	96	352	19 52 31.2	320	217	21 06 58.5	119	27
+14 18.0	− 90 47.0	18 22 27.7	296	140	19 46 43.4	109	4	19 52 55.5	307	204	21 07 14.7	119	26
+14 38.0	− 90 32.0	18 22 39.9	296	142	19 47 06.6	87	344	19 52 29.6	329	226	21 07 02.5	119	27
+14 04.0	− 90 23.0	18 23 49.1	296	143	19 47 52.0	108	3	19 54 00.6	309	205	21 08 02.8	119	26

Dot leaders indicate the phenomenon occurs below the horizon. Blanks indicate the phenomenon does not occur for the location.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		Name of Location	Duration of Totality	Maximum Eclipse					
Latitude	Longitude			Path Width	U.T.	Obscur.	Mag.	Sun's Alt.	Sun's Az.
° ′	° ′	***Guatemala (cont.)***	m s	km	h m s	%		°	°
+15 19.0	− 91 28.0	Huehuetenango	5 16.9	257	19 46 58.6	100.0	1.018	66	290
+14 38.0	− 89 59.0	Jalapa	3 55.7	257	19 50 51.0	100.0	1.009	64	291
+14 31.0	− 91 30.0	Mazatenango	6 19.6	257	19 48 07.1	100.0	1.038	66	292
+14 51.0	− 91 31.0	Quezaltenango	6 12.6	257	19 47 35.0	100.0	1.032	66	291
+14 31.0	− 91 40.0	Retalhuleu	6 18.2	257	19 47 47.4	100.0	1.035	66	292
+15 06.0	− 90 19.0	Salama	2 02.7	257	19 49 31.1	100.0	1.002	65	290
+13 56.0	− 90 50.0	San Jose	6 13.5	256	19 50 17.5	100.0	1.034	65	292
		El Salvador							
+13 56.0	− 89 51.0	Ahuachapan	5 49.4	256	19 52 09.2	100.0	1.026	63	292
+14 03.0	− 88 56.0	Chalatenango	2 59.2	256	19 53 39.7	100.0	1.005	62	291
+13 43.0	− 88 56.0	Cojutepeque	4 43.2	256	19 54 09.7	100.0	1.014	62	291
+13 20.0	− 87 50.0	La Union	2 29.9	255	19 56 41.3	100.0	1.003	60	291
+13 28.0	− 88 10.0	San Miguel	3 18.0	256	19 55 54.3	100.0	1.006	61	291
+13 42.0	− 89 12.0	San Salvador	5 20.6	256	19 53 42.1	100.0	1.020	62	292
+14 00.0	− 89 33.0	Santa Ana	5 12.8	256	19 52 36.5	100.0	1.018	63	291
+13 43.0	− 89 44.0	Sonsonate	6 00.0	256	19 52 41.7	100.0	1.030	63	292
+13 20.0	− 88 26.0	Usulutan	4 48.6	256	19 55 37.8	100.0	1.015	61	292
+13 30.0	− 88 52.0	Zacatecoluca	5 14.4	256	19 54 36.3	100.0	1.019	62	292
		Honduras							
+13 16.0	− 87 39.0	Amapala	1 47.8	255	19 57 06.3	100.0	1.002	60	291
+13 18.0	− 87 12.0	Choluteca			19 57 49.8	99.4	0.988	59	291
+13 33.0	− 87 26.0	Nacaome			19 57 03.5	99.3	0.986	60	291
+15 26.0	− 88 01.0	San Pedro Sula			19 53 12.9	95.0	0.948	62	288
+14 05.0	− 87 14.0	Tegucigalpa			19 56 36.4	97.5	0.970	60	290
		Nicaragua							
+12 00.0	− 83 49.0	Bluefields			20 05 10.8	96.5	0.961	54	291
+12 38.0	− 87 08.0	Chinandega	3 50.7	255	19 58 55.8	100.0	1.009	59	292
+11 56.0	− 85 58.0	Granada	3 00.1	254	20 01 54.0	100.0	1.005	57	292
+11 51.0	− 86 12.0	Jinotepe	4 18.6	254	20 01 38.3	100.0	1.012	57	293
+12 25.0	− 86 53.0	Leon	4 01.1	255	19 59 40.4	100.0	1.010	58	292
+12 08.0	− 86 17.0	Managua	3 11.9	254	20 01 05.3	100.0	1.006	57	292
+11 58.0	− 86 06.0	Masaya	3 24.4	254	20 01 38.0	100.0	1.007	57	292
+12 52.0	− 85 58.0	Matagalpa			20 00 32.0	98.5	0.979	57	291
+11 45.0	− 86 03.0	Nandaime	4 16.2	254	20 02 01.8	100.0	1.012	57	293
+11 26.0	− 85 50.0	Rivas	4 48.1	254	20 02 50.5	100.0	1.016	56	293
+12 12.0	− 86 06.0	Tipitapa	1 09.4	254	20 01 17.5	100.0	1.001	57	292
		Costa Rica							
+10 01.0	− 84 13.0	Alajuela	5 15.1	252	20 07 23.7	100.0	1.023	53	294
+ 9 51.0	− 83 55.0	Cartago	5 08.1	252	20 08 04.9	100.0	1.022	53	294
+ 9 59.0	− 84 07.0	Heredia	5 10.4	252	20 07 35.6	100.0	1.022	53	294
+10 06.0	− 85 22.0	La Mansion	5 46.0	253	20 05 29.8	100.0	1.034	55	294
+ 9 57.0	− 85 02.0	Lepanto	5 46.5	252	20 06 13.9	100.0	1.036	54	294
+10 38.0	− 85 26.0	Liberia	5 41.7	253	20 04 38.0	100.0	1.030	55	294
+ 9 59.0	− 83 01.0	Limon	0 41.0	252	20 09 13.4	100.0	1.000	52	293
+ 9 28.0	− 84 10.0	Puerto Quepos	5 42.6	252	20 08 14.4	100.0	1.037	53	294
+ 9 58.0	− 84 50.0	Puntarenas	5 46.0	252	20 06 31.2	100.0	1.037	54	294
+ 9 56.0	− 84 04.0	San Jose	5 11.7	252	20 07 44.3	100.0	1.022	53	294
+ 9 56.0	− 83 41.0	Turrialba	4 29.3	252	20 08 18.8	100.0	1.015	53	294
		Panama							
+ 7 59.0	− 80 26.0	Chitre	2 14.5	250	20 15 28.6	100.0	1.003	47	294
+ 9 21.0	− 79 54.0	Colon			20 14 21.0	95.8	0.955	47	293
+ 8 26.0	− 82 26.0	David	5 27.6	250	20 12 10.7	100.0	1.031	50	294
+ 7 46.0	− 80 16.0	Las Tablas	2 54.7	249	20 15 58.5	100.0	1.006	47	294
+ 8 57.0	− 79 30.0	Panama City			20 15 23.6	96.2	0.959	47	293
+ 8 18.0	− 82 52.0	Puerto Armuelles	5 32.9	250	20 11 44.8	100.0	1.033	50	295
+ 8 06.0	− 80 59.0	Santiago	3 51.2	250	20 14 36.2	100.0	1.011	48	294
		Colombia							
+ 4 32.0	− 75 42.0	Armenia	2 25.0	244	20 25 13.3	100.0	1.005	39	295
+11 10.0	− 74 50.0	Barranquilla			20 17 52.7	77.5	0.809	43	290
+ 4 38.0	− 74 05.0	Bogota			20 26 42.5	97.3	0.968	37	294
+ 3 53.0	− 77 04.0	Buenaventura	4 48.9	244	20 24 31.9	100.0	1.025	40	296
+ 3 54.0	− 76 18.0	Buga	5 00.4	244	20 25 19.6	100.0	1.033	40	296
+ 3 25.0	− 76 30.0	Cali	4 40.3	244	20 25 40.0	100.0	1.023	39	296
+ 2 41.0	− 75 20.0	Campoalegre	4 41.2	242	20 27 39.8	100.0	1.025	38	296
+ 4 08.0	− 74 53.0	Espinal			20 26 30.0	99.9	0.994	38	295
+ 2 13.0	− 75 39.0	Garzon	2 45.5	242	20 27 51.3	100.0	1.006	38	296
+ 4 26.0	− 75 15.0	Ibague			20 25 47.6	99.9	0.996	39	295

Assumed to be sea level, except observatories.

Names and spelling are not authoritative, nor do they imply any official recognition of status.

No correction for elevation, limb or refraction included.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		First Contact			Second Contact			Third Contact			Fourth Contact		
Latitude	Longitude	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*
° ′	° ′	h m s	°	°	h m s	°	°	h m s	°	°	h m s	°	°
+15 19.0	– 91 28.0	18 19 19.4	295	131	19 44 19.6	84	341	19 49 36.5	331	229	21 04 55.6	119	28
+14 38.0	– 89 59.0	18 24 05.7	295	146	19 48 52.7	67	325	19 52 48.5	349	247	21 07 39.4	120	28
+14 31.0	– 91 30.0	18 20 17.8	296	132	19 44 56.6	120	15	19 51 16.3	296	192	21 06 04.6	118	25
+14 51.0	– 91 31.0	18 19 48.2	296	131	19 44 28.0	106	2	19 50 40.6	309	206	21 05 34.0	119	26
+14 31.0	– 91 40.0	18 19 51.6	297	130	19 44 37.7	124	19	19 50 55.9	291	188	21 05 52.4	118	25
+15 06.0	– 90 19.0	18 22 37.2	295	143	19 48 29.4	47	305	19 50 32.2	9	267	21 06 34.8	120	29
+13 56.0	– 90 50.0	18 22 50.1	297	140	19 47 10.0	125	20	19 53 23.6	291	187	21 07 43.1	118	25
+13 56.0	– 89 51.0	18 25 22.7	296	148	19 49 13.8	98	354	19 55 03.3	318	215	21 08 50.5	119	26
+14 03.0	– 88 56.0	18 27 34.8	295	154	19 52 09.7	57	315	19 55 08.9	359	257	21 09 39.0	120	28
+13 43.0	– 88 56.0	18 28 01.6	296	154	19 51 47.5	79	335	19 56 30.8	338	236	21 10 08.6	120	27
+13 20.0	– 87 50.0	18 31 20.5	295	160	19 55 25.9	53	310	19 57 55.9	4	262	21 11 49.0	120	28
+13 28.0	– 88 10.0	18 30 19.1	295	158	19 54 14.8	61	319	19 57 32.9	355	253	21 11 17.5	120	28
+13 42.0	– 89 12.0	18 27 22.0	296	152	19 51 01.2	88	345	19 56 21.8	328	225	21 09 53.2	119	27
+14 00.0	– 89 33.0	18 26 03.7	296	150	19 49 59.6	86	342	19 55 12.4	331	228	21 09 04.3	119	27
+13 43.0	– 89 44.0	18 25 58.5	296	148	19 49 41.0	104	359	19 55 41.0	313	210	21 09 17.1	119	26
+13 20.0	– 88 26.0	18 29 49.3	296	157	19 53 13.0	80	337	19 58 01.6	336	234	21 11 13.1	120	27
+13 30.0	– 88 52.0	18 28 29.5	296	154	19 51 58.5	87	343	19 57 13.0	329	227	21 10 31.7	119	27
+13 16.0	– 87 39.0	18 31 53.6	295	161	19 56 12.1	46	303	19 57 59.9	11	269	21 12 05.5	120	28
+13 18.0	– 87 12.0	18 32 58.9	295	163							21 12 28.2	121	29
+13 33.0	– 87 26.0	18 32 03.8	295	162							21 11 52.8	121	29
+15 26.0	– 88 01.0	18 28 11.5	292	160							21 08 24.8	123	33
+14 05.0	– 87 14.0	18 31 52.6	294	163							21 11 15.7	122	31
+12 00.0	– 83 49.0	18 42 59.6	294	172							21 17 11.7	122	31
+12 38.0	– 87 08.0	18 34 03.0	296	163	19 57 00.0	68	326	20 00 50.8	348	246	21 13 30.1	120	27
+11 56.0	– 85 58.0	18 37 53.2	296	166	20 00 23.5	59	316	20 03 23.7	358	256	21 15 33.3	120	27
+11 51.0	– 86 12.0	18 37 26.0	296	166	19 59 28.5	75	332	20 03 47.1	342	239	21 15 27.9	120	27
+12 25.0	– 86 53.0	18 34 58.1	296	163	19 57 39.3	71	328	20 01 40.5	346	244	21 14 02.6	120	27
+12 08.0	– 86 17.0	18 36 50.2	296	166	19 59 28.9	61	319	20 02 40.9	356	254	21 14 59.6	120	27
+11 58.0	– 86 06.0	18 37 31.0	296	166	19 59 55.3	64	321	20 03 19.8	353	251	21 15 23.5	120	27
+12 52.0	– 85 58.0	18 36 37.8	294	167							21 14 12.8	121	30
+11 45.0	– 86 03.0	18 37 56.3	296	166	19 59 53.2	75	332	20 04 09.4	342	240	21 15 44.3	120	27
+11 26.0	– 85 50.0	18 38 54.3	297	167	20 00 25.8	83	340	20 05 14.0	334	231	21 16 22.0	119	26
+12 12.0	– 86 06.0	18 37 11.8	296	166	20 00 42.5	40	298	20 01 52.0	17	275	21 15 03.7	120	28
+10 01.0	– 84 13.0	18 44 44.1	297	171	20 04 45.5	95	351	20 10 00.7	322	219	21 19 37.2	119	25
+ 9 51.0	– 83 55.0	18 45 39.9	297	171	20 05 30.2	93	349	20 10 38.3	324	222	21 20 04.5	119	25
+ 9 59.0	– 84 07.0	18 45 00.9	297	171	20 04 59.8	93	350	20 10 10.2	324	221	21 19 44.6	119	25
+10 06.0	– 85 22.0	18 41 55.7	298	168	20 02 36.1	126	21	20 08 22.1	291	187	21 18 32.8	118	24
+ 9 57.0	– 85 02.0	18 42 55.7	298	169	20 03 20.0	122	18	20 09 06.5	295	191	21 19 01.7	118	24
+10 38.0	– 85 26.0	18 40 59.9	298	168	20 01 46.4	106	2	20 07 28.1	311	208	21 17 47.6	119	25
+ 9 59.0	– 83 01.0	18 47 32.9	296	173	20 08 52.6	36	293	20 09 33.6	22	279	21 20 34.9	120	27
+ 9 28.0	– 84 10.0	18 45 38.3	298	171	20 05 22.3	117	12	20 11 05.0	301	197	21 20 22.0	118	24
+ 9 58.0	– 84 50.0	18 43 22.3	298	169	20 03 37.5	116	11	20 09 23.5	301	198	21 19 10.6	118	24
+ 9 56.0	– 84 04.0	18 45 12.1	297	171	20 05 07.9	94	350	20 10 19.6	323	220	21 19 50.9	119	25
+ 9 56.0	– 83 41.0	18 46 05.2	297	172	20 06 03.5	81	337	20 10 32.9	337	234	21 20 08.9	119	26
+ 7 59.0	– 80 26.0	18 55 58.4	297	177	20 14 21.0	53	310	20 16 35.5	4	262	21 24 51.0	120	26
+ 9 21.0	– 79 54.0	18 55 20.6	294	177							21 23 24.3	122	30
+ 8 26.0	– 82 26.0	18 51 01.1	298	174	20 09 26.2	108	3	20 14 53.9	310	206	21 22 58.5	119	24
+ 7 46.0	– 80 16.0	18 56 37.1	297	177	20 14 30.8	61	318	20 17 25.5	356	253	21 25 12.9	120	25
+ 8 57.0	– 79 30.0	18 56 42.7	294	177							21 24 09.1	122	29
+ 8 18.0	– 82 52.0	18 50 15.2	299	173	20 08 57.6	126	21	20 14 30.5	291	188	21 22 49.1	118	23
+ 8 06.0	– 80 59.0	18 54 38.3	297	176	20 12 40.0	74	330	20 16 31.3	344	241	21 24 22.0	119	25
+ 4 32.0	– 75 42.0	19 09 47.5	297	180	20 24 00.4	57	314	20 26 25.5	359	257	21 31 09.8	119	24
+11 10.0	– 74 50.0	19 04 10.6	286	179							21 22 45.4	130	41
+ 4 38.0	– 74 05.0	19 12 34.9	295	181							21 31 37.9	121	26
+ 3 53.0	– 77 04.0	19 08 07.8	299	180	20 22 06.8	137	32	20 26 55.8	280	176	21 31 13.3	117	21
+ 3 54.0	– 76 18.0	19 09 30.0	299	180	20 22 48.7	113	9	20 27 49.2	304	200	21 31 33.7	118	22
+ 3 25.0	– 76 30.0	19 09 46.1	299	181	20 23 19.2	140	35	20 27 59.5	276	172	21 31 56.7	117	20
+ 2 41.0	– 75 20.0	19 12 45.4	299	181	20 25 18.6	136	32	20 29 59.8	280	176	21 33 08.9	117	20
+ 4 08.0	– 74 53.0	19 11 44.9	297	181							21 31 53.7	119	24
+ 2 13.0	– 75 39.0	19 12 48.9	300	181	20 26 28.1	174	69	20 29 13.7	242	137	21 33 26.1	116	18
+ 4 26.0	– 75 15.0	19 10 43.8	297	181							21 31 26.6	119	24

Dot leaders indicate the phenomenon occurs below the horizon. Blanks indicate the phenomenon does not occur for the location.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		Name of Location	Duration of Totality	Maximum Eclipse					
Latitude	Longitude			Path Width	U.T.	Obscur.	Mag.	Sun's Alt.	Sun's Az.
° ′	° ′	***Colombia (cont.)***	m s	km	h m s	%		°	°
− 1 16.0	− 69 43.0	La Pedrera	3 56.7	235	20 36 15.9	100.0	1.018	29	296
+ 6 15.0	− 75 36.0	Medellin			20 23 18.2	95.7	0.954	40	294
+ 1 24.0	− 72 06.0	Miraflores	4 20.2	239	20 31 56.1	100.0	1.022	33	296
+ 1 07.0	− 70 05.0	Mitu			20 33 48.0	99.4	0.989	31	295
+ 2 57.0	− 75 17.0	Neiva	4 55.2	243	20 27 25.3	100.0	1.033	38	296
+ 3 32.0	− 76 18.0	Palmira	4 56.3	244	20 25 44.6	100.0	1.030	39	296
+ 4 48.0	− 75 40.0	Pereira			20 24 56.9	99.9	0.997	39	295
+ 2 35.0	− 72 35.0	San Jose del Guaviare			20 30 18.7	99.9	0.998	34	295
+ 4 05.0	− 76 12.0	Tulua	4 49.4	244	20 25 13.3	100.0	1.027	40	295
		Brazil							
−12 55.0	− 46 56.0	Arraias	3 09.1	206	20 48 52.7	100.0	1.024	1	293
−23 11.0	− 46 33.8	Atibaia (Itapetinga Radio Obs.)			.. ..	... .	. ...	...	...
−19 49.3	− 43 30.7	Belo Horizonte (Piedade Obs.)			.. ..	... .	. ...	...	...
−15 45.0	− 47 57.0	Brasilia			20 49 35.8	91.6	0.923	0	293
− 9 22.0	− 54 55.0	Cachimbo	3 27.2	216	20 47 28.9	100.0	1.023	10	294
− 4 06.0	− 63 08.0	Coari	3 33.5	228	20 42 12.3	100.0	1.018	20	295
− 3 50.0	− 62 04.0	Codajas			20 42 27.6	99.0	0.984	19	295
− 2 32.0	− 66 01.0	Fonte Boa	3 58.2	231	20 39 37.6	100.0	1.022	24	296
−11 48.0	− 49 32.0	Formoso	3 15.8	209	20 48 41.8	100.0	1.024	3	293
−22 31.1	− 45 33.9	Itajuba (National Obs. Sta.)			.. ..	... .	. ...	...	...
− 6 15.0	− 57 39.0	Jacareacanga			20 45 23.9	99.4	0.990	14	295
− 1 37.0	− 67 59.0	Julia	4 21.4	234	20 37 43.1	100.0	1.031	27	296
− 3 06.0	− 60 00.0	Manaus			20 42 42.5	93.3	0.935	18	294
−12 42.0	− 46 24.0	Manha	2 53.2	206	20 48 46.1	100.0	1.025	0	293
− 5 50.0	− 61 17.0	Manicore	3 56.0	224	20 44 04.6	100.0	1.031	18	295
− 5 06.0	− 60 22.0	Novo Aripuana	0 49.9	225	20 43 55.7	100.0	1.001	17	295
−30 03.2	− 51 07.6	Porto Alegre (Morro Santana Obs.)			.. ..	... .	. ...	...	...
−10 41.0	− 48 19.0	Porto Nacional			20 48 17.0	98.5	0.980	3	293
− 8 06.0	− 34 53.0	Recife			.. ..	... .	. ...	...	...
−22 53.7	− 43 13.4	Rio de Janeiro (National Obs.)			.. ..	... .	. ...	...	...
−11 33.0	− 50 37.0	Santa Isabel do Morro	3 02.0	210	20 48 37.4	100.0	1.017	5	294
−23 33.0	− 46 39.0	Sao Paulo			.. ..	... .	. ...	...	...
− 3 34.0	− 68 55.0	Sao Paulo de Olivenca			20 38 42.9	96.9	0.965	27	297
− 3 23.0	− 64 43.0	Tefe	3 58.2	230	20 40 57.3	100.0	1.024	22	296
− 0 07.0	− 67 05.0	Uaupes			20 36 58.8	97.4	0.969	27	295
		United States (except Hawaii)							
+35 05.0	−106 38.0	Albuquerque, NM			18 50 36.1	56.0	0.637	76	159
+33 46.7	− 84 19.1	Atlanta, GA (Fernbank Obs.)			19 31 38.4	28.2	0.391	63	251
+34 15.2	−116 54.9	Big Bear Lake, CA (Solar Obs.)			18 30 31.3	67.6	0.731	68	118
+25 54.0	− 97 30.0	Brownsville, TX			19 19 05.9	78.1	0.814	79	251
+41 50.0	− 87 38.0	Chicago, IL			19 16 09.2	12.8	0.227	64	227
+39 08.3	− 84 25.4	Cincinnati, OH (Cincinnati Obs.)			19 24 03.0	15.1	0.255	63	239
+32 47.0	− 96 48.0	Dallas, TX			19 11 54.7	51.5	0.599	76	222
+39 40.6	−104 57.2	Denver, CO (Chamberlin Obs.)			18 50 37.4	37.3	0.477	72	169
+42 23.0	− 88 05.0	Detroit, MI			19 14 52.4	12.1	0.218	64	224
+31 45.0	−106 29.0	El Paso, TX			18 53 25.7	69.1	0.743	80	156
+35 11.0	−111 44.4	Flagstaff, AZ (US Naval Obs. Sta.)			18 40 26.5	60.4	0.673	73	136
+29 45.0	− 95 25.0	Houston, TX			19 18 17.3	60.0	0.670	76	239
+39 02.0	− 94 33.0	Kansas City, MO			19 08 52.2	27.9	0.389	71	213
+31 57.8	−111 36.0	Kitt Peak, AZ (National Obs.)			18 42 20.0	73.6	0.778	75	129
+36 10.0	−115 10.0	Las Vegas, NV			18 33 28.8	58.7	0.659	69	127
+34 07.1	−118 17.9	Los Angeles, CA (Griffith Obs.)			18 27 51.0	68.8	0.741	67	115
+25 45.0	− 80 15.0	Miami, FL			19 49 37.0	43.5	0.531	57	271
+45 00.0	− 93 15.0	Minneapolis, MN			19 04 50.1	11.1	0.207	65	206
+37 20.6	−121 38.2	Mount Hamilton, CA (Lick Obs.)			18 21 38.5	56.4	0.640	62	115
+31 41.3	−110 53.1	Mount Hopkins, AZ (MMT Obs.)			18 44 01.4	74.1	0.782	76	131
+32 26.5	−110 47.5	Mount Lemmon, AZ (Infrared Obs.)			18 43 46.8	70.9	0.757	76	133
+30 40.3	−104 01.3	Mount Locke, TX (McDonald Obs.)			18 59 37.5	70.3	0.752	81	177
+34 13.0	−118 03.6	Mount Wilson, CA (Hale Obs.)			18 28 17.3	68.3	0.736	67	116
+30 00.0	− 90 03.0	New Orleans, LA			19 27 48.7	49.4	0.582	70	252
+40 48.6	− 73 57.5	New York, NY (Rutherford Obs.)			19 34 35.7	2.2	0.069	53	252
+41 15.0	− 96 00.0	Omaha, NE			19 04 18.0	23.2	0.342	69	204
+33 21.4	−116 51.8	Palomar Mtn., CA (Palomar Obs.)			18 30 49.6	71.4	0.761	69	117
+39 57.5	− 75 10.4	Philadelphia, PA (Franklin Inst.)			19 34 30.3	4.1	0.106	54	252
+33 30.0	−112 03.0	Phoenix, AZ			18 40 36.8	67.6	0.730	74	131
+40 29.0	− 80 01.3	Pittsburgh, PA (Allegheny Obs.)			19 28 00.4	7.7	0.161	58	244

Assumed to be sea level, except observatories.

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No correction for elevation, limb or refraction included.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		First Contact			Second Contact			Third Contact			Fourth Contact		
Latitude	Longitude	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*
° ′	° ′	h m s	°	°	h m s	°	°	h m s	°	°	h m s	°	°
− 1 16.0	− 69 43.0	19 26 00.0	299	184	20 34 17.0	146	41	20 38 13.7	269	164	21 38 08.0	115	18
+ 6 15.0	− 75 36.0	19 07 54.6	294	180							21 29 16.4	122	28
+ 1 24.0	− 72 06.0	19 19 35.3	298	182	20 29 45.4	95	351	20 34 05.7	320	217	21 35 24.9	118	21
+ 1 07.0	− 70 05.0	19 22 57.7	296	183							21 36 07.3	119	23
+ 2 57.0	− 75 17.0	19 12 30.3	299	181	20 24 57.1	123	19	20 29 52.3	293	189	21 32 55.1	117	21
+ 3 32.0	− 76 18.0	19 09 58.4	299	181	20 23 15.8	129	24	20 28 12.1	288	184	21 31 55.4	117	21
+ 4 48.0	− 75 40.0	19 09 31.5	296	180							21 30 53.5	120	25
+ 2 35.0	− 72 35.0	19 17 28.6	296	182							21 34 11.2	119	24
+ 4 05.0	− 76 12.0	19 09 26.8	298	180	20 22 48.0	102	358	20 27 37.4	315	211	21 31 25.3	118	22
−12 55.0	− 46 56.0	19 52 05.0	295	185	20 47 17.8	127	23	20 50 26.9	279	175	.. ..	...	...
−23 11.0	− 46 33.8	19 56 32.0	312	193							.. ..	...	...
−19 49.3	− 43 30.7	19 55 08.7	304	189							.. ..	...	...
−15 45.0	− 47 57.0	19 52 53.0	300	188							.. ..	...	...
− 9 22.0	− 54 55.0	19 46 50.5	296	185	20 45 44.9	131	27	20 49 12.1	278	174	.. ..	...	...
− 4 06.0	− 63 08.0	19 36 31.6	296	184	20 40 25.1	87	344	20 43 58.6	326	222	21 40 36.8	116	19
− 3 50.0	− 62 04.0	19 37 24.9	295	184							21 40 23.4	117	21
− 2 32.0	− 66 01.0	19 31 57.8	297	184	20 37 37.9	96	352	20 41 36.2	318	215	21 39 31.5	116	19
−11 48.0	− 49 32.0	19 50 44.2	295	185	20 47 03.6	127	23	20 50 19.4	280	176	.. ..	...	...
−22 31.1	− 45 33.9	19 56 13.3	310	192							.. ..	...	...
− 6 15.0	− 57 39.0	19 43 05.5	294	184							21 41 17.2	117	20
− 1 37.0	− 67 59.0	19 28 39.1	298	184	20 35 31.9	110	6	20 39 53.3	304	200	21 38 40.8	116	19
− 3 06.0	− 60 00.0	19 38 58.8	292	183							21 39 38.3	120	25
−12 42.0	− 46 24.0	19 52 10.5	294	185	20 47 10.7	102	358	.. ..	...	...	.. ..	...	...
− 5 50.0	− 61 17.0	19 39 41.4	297	185	20 42 06.1	121	17	20 46 02.1	291	187	21 41 31.4	115	17
− 5 06.0	− 60 22.0	19 39 59.7	295	184	20 43 30.5	38	295	20 44 20.4	14	271	21 41 01.9	117	20
−30 03.2	− 51 07.6	20 01 43.6	328	202							.. ..	...	...
−10 41.0	− 48 19.0	19 50 48.6	292	184							.. ..	...	...
− 8 06.0	− 34 53.0	19 54 17.0	277	177							.. ..	...	...
−22 53.7	− 43 13.4	19 56 18.9	309	192							.. ..	...	...
−11 33.0	− 50 37.0	19 50 10.6	296	185	20 47 06.1	141	36	20 50 08.1	267	163	.. ..	...	...
−23 33.0	− 46 39.0	19 56 42.8	313	194							.. ..	...	...
− 3 34.0	− 68 55.0	19 29 30.0	302	185							21 39 47.0	112	13
− 3 23.0	− 64 43.0	19 34 13.2	297	184	20 38 57.7	99	355	20 42 55.9	315	211	21 40 09.3	116	19
− 0 07.0	− 67 05.0	19 28 23.8	294	183							21 37 34.6	119	24
+35 05.0	−106 38.0	17 35 07.4	265	319							20 05 41.9	135	95
+33 46.7	− 84 19.1	18 30 19.0	256	216							20 29 01.5	154	91
+34 15.2	−116 54.9	17 14 40.8	267	329							19 49 37.2	126	130
+25 54.0	− 97 30.0	17 54 23.7	280	347							20 38 22.0	129	52
+41 50.0	− 87 38.0	18 28 41.5	241	224							20 01 57.0	165	119
+39 08.3	− 84 25.4	18 34 02.5	244	214							20 11 48.4	163	110
+32 47.0	− 96 48.0	17 56 41.5	267	302							20 23 36.2	140	79
+39 40.6	−104 57.2	17 43 54.7	255	296							19 56 52.4	144	115
+42 23.0	− 88 05.0	18 28 19.6	240	224							19 59 52.7	165	121
+31 45.0	−106 29.0	17 33 02.9	272	333							20 13 01.9	129	77
+35 11.0	−111 44.4	17 24 53.9	265	324							19 57 20.8	131	110
+29 45.0	− 95 25.0	17 59 29.0	272	310							20 32 22.6	136	68
+39 02.0	− 94 33.0	18 07 06.0	253	264							20 08 26.4	152	105
+31 57.8	−111 36.0	17 22 22.4	272	336							20 03 40.6	126	91
+36 10.0	−115 10.0	17 19 51.8	263	322							19 49 30.9	131	128
+34 07.1	−118 17.9	17 12 17.6	267	330							19 47 08.7	125	137
+25 45.0	− 80 15.0	18 41 02.9	267	193							20 51 55.4	146	71
+45 00.0	− 93 15.0	18 19 32.8	238	237							19 49 07.1	165	131
+37 20.6	−121 38.2	17 11 31.3	260	319							19 35 42.7	130	155
+31 41.3	−110 53.1	17 23 37.2	272	337							20 05 30.0	126	87
+32 26.5	−110 47.5	17 24 19.4	271	334							20 04 16.9	127	91
+30 40.3	−104 01.3	17 38 10.6	273	335							20 19 09.3	130	70
+34 13.0	−118 03.6	17 12 46.0	267	329							19 47 27.2	126	136
+30 00.0	− 90 03.0	18 13 48.9	268	255							20 36 31.3	142	73
+40 48.6	− 73 57.5	19 09 07.2	225	177							19 59 27.9	183	130
+41 15.0	− 96 00.0	18 06 20.5	249	262							20 00 40.1	155	115
+33 21.4	−116 51.8	17 13 51.1	269	332							19 51 10.3	125	127
+39 57.5	− 75 10.4	19 02 57.5	230	182							20 05 02.7	178	124
+33 30.0	−112 03.0	17 22 43.1	269	330							20 00 02.5	128	102
+40 29.0	− 80 01.3	18 48 31.7	236	197							20 06 00.2	172	120

Dot leaders indicate the phenomenon occurs below the horizon. Blanks indicate the phenomenon does not occur for the location.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		Name of Location	Duration of Totality	Maximum Eclipse					
Latitude	Longitude			Path Width	U.T.	Obscur.	Mag.	Sun's Alt.	Sun's Az.
° ′	° ′	***United States (cont.)***	m s	km	h m s	%		°	°
+40 45.0	−111 55.0	Salt Lake City, UT			18 38 04.8	39.0	0.491	68	144
+32 45.0	−117 10.0	San Diego, CA			18 30 22.0	74.2	0.783	69	115
+37 45.0	−122 27.0	San Francisco, CA			18 20 19.1	54.8	0.627	61	114
+18 29.0	− 66 08.0	San Juan, PR			20 16 00.3	35.9	0.464	37	284
+47 35.0	−122 20.0	Seattle, WA			18 22 39.2	19.6	0.304	56	129
+34 04.7	−107 37.1	Socorro, NM (National Radio Obs.)			18 49 19.4	61.0	0.678	77	152
+38 40.0	− 90 15.0	St. Louis, MO			19 16 06.8	23.5	0.345	68	227
+32 47.2	−105 49.2	Sunspot, NM (National Solar Obs.)			18 53 58.1	64.1	0.703	79	162
+32 14.0	−110 56.9	Tucson, AZ (Steward Obs.)			18 43 34.8	71.9	0.765	76	132
+38 55.3	− 77 04.0	Washington, DC (US Naval Obs.)			19 33 50.0	7.4	0.156	56	251
		Other Locations							
−25 15.0	− 57 40.0	Asuncion, Paraguay			20 49 38.7	40.2	0.504	5	297
+17 13.0	− 88 48.0	Belmopan, Belize			19 49 06.7	90.9	0.915	64	285
−34 40.0	− 58 30.0	Buenos Aires, Argentina			20 46 29.2	11.7	0.215	1	298
+51 05.0	−114 05.0	Calgary, Canada			18 33 37.0	8.7	0.174	58	149
+10 35.0	− 66 56.0	Caracas, Venezuela			20 25 44.5	61.2	0.680	33	290
−29 15.4	− 70 43.8	Cerro La Silla, Chile (ESO)			20 44 48.7	10.4	0.197	13	305
−29 00.5	− 70 42.0	Cerro Las Campanas, Chile (Obs.)			20 44 53.5	10.9	0.205	13	305
−30 09.9	− 70 48.9	Cerro Tololo, Chile (CTIO)			20 44 30.2	8.4	0.171	13	305
−31 25.3	− 64 11.8	Cordoba, Argentina (Astro. Obs.)			20 46 41.9	13.1	0.232	7	301
+53 34.0	−113 25.0	Edmonton, Canada			18 34 29.6	3.6	0.097	56	152
+23 07.0	− 82 25.0	Havana, Cuba			19 50 33.2	56.1	0.638	59	275
+17 58.0	− 76 48.0	Kingston, Jamaica			20 06 01.4	59.9	0.669	49	283
−16 30.0	− 68 10.0	La Paz, Bolivia			20 46 00.1	52.1	0.605	18	301
−12 06.0	− 77 03.0	Lima, Peru			20 38 14.6	48.7	0.577	29	304
−34 55.0	− 56 10.0	Montevideo, Uruguay			.. ..	... .	. ...	...	...
+18 33.0	− 72 20.0	Port-au-Prince, Haiti			20 10 13.0	48.2	0.572	44	283
− 0 14.0	− 78 30.0	Quito, Ecuador			20 27 27.8	86.8	0.883	39	299
−33 30.0	− 70 40.0	Santiago, Chile			20 43 15.6	2.8	0.081	11	306
+18 30.0	− 69 57.0	Santo Domingo, Dominican Republic			20 12 39.2	43.4	0.531	41	284
+49 13.0	−123 06.0	Vancouver, Canada			18 22 14.0	15.0	0.253	55	129
+49 53.0	− 97 10.0	Winnipeg, Canada			18 55 36.0	4.3	0.108	62	191

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LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		First Contact			Second Contact			Third Contact			Fourth Contact		
Latitude	Longitude	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*
° ′	° ′	h m s	°	°	h m s	°	°	h m s	°	°	h m s	°	°
+40 45.0	−111 55.0	17 32 07.8	254	301							19 45 07.9	141	134
+32 45.0	−117 10.0	17 12 47.1	270	335							19 51 31.1	124	127
+37 45.0	−122 27.0	17 11 04.2	259	317							19 33 35.0	130	158
+18 29.0	− 66 08.0	19 17 51.6	264	176							21 08 44.5	149	70
+47 35.0	−122 20.0	17 32 04.3	238	280							19 14 50.0	151	173
+34 04.7	−107 37.1	17 32 08.8	267	324							20 06 22.6	132	92
+38 40.0	− 90 15.0	18 17 44.5	251	243							20 11 57.5	156	104
+32 47.2	−105 49.2	17 35 06.3	270	328							20 11 55.6	132	82
+32 14.0	−110 56.9	17 23 52.8	271	335							20 04 23.1	127	91
+38 55.3	− 77 04.0	18 55 14.7	236	189							20 10 51.6	173	117
−25 15.0	− 57 40.0	19 57 53.3	326	200							.. .. ..	...	...
+17 13.0	− 88 48.0	18 24 06.1	290	159							21 04 42.4	125	37
−34 40.0	− 58 30.0	20 10 09.4	346	214							.. .. ..	...	...
+51 05.0	−114 05.0	17 53 46.1	229	259							19 13 54.6	163	172
+10 35.0	− 66 56.0	19 20 07.7	278	178							21 24 11.5	136	50
−29 15.4	− 70 43.8	20 06 27.4	350	215							21 20 56.0	61	296
−29 00.5	− 70 42.0	20 05 52.4	349	214							21 21 35.3	62	297
−30 09.9	− 70 48.9	20 08 40.6	352	217							21 18 24.8	58	292
−31 25.3	− 64 11.8	20 07 29.7	346	213							21 23 38.4	63	299
+53 34.0	−113 25.0	18 04 39.6	221	245							19 04 31.2	172	182
+23 07.0	− 82 25.0	18 36 19.7	274	190							20 57 23.6	140	61
+17 58.0	− 76 48.0	18 53 55.8	277	181							21 10 11.6	138	55
−16 30.0	− 68 10.0	19 45 23.8	322	196							21 40 31.1	91	340
−12 06.0	− 77 03.0	19 32 46.8	325	193							21 36 26.9	91	340
−34 55.0	− 56 10.0	20 09 14.1	344	212							.. .. ..	...	...
+18 33.0	− 72 20.0	19 04 06.9	271	180							21 09 29.1	143	62
− 0 14.0	− 78 30.0	19 11 30.8	307	182							21 33 44.2	109	8
−33 30.0	− 70 40.0	20 18 18.7	2	226							21 07 23.3	47	277
+18 30.0	− 69 57.0	19 09 33.2	268	179							21 09 27.2	146	65
+49 13.0	−123 06.0	17 35 59.1	234	274							19 09 47.5	155	177
+49 53.0	− 97 10.0	18 22 58.8	226	230							19 27 56.2	174	156

Dot leaders indicate the phenomenon occurs below the horizon. Blanks indicate the phenomenon does not occur for the location.

LIMB CORRECTIONS

The information below is based largely on the article, "Correcting Predictions of Solar Eclipse Contact Times for the Effects of Lunar Limb Irregularities", *J. Brit. Astron. Assoc.* 1983, **93**, 6, pp. 241-246, by David Herald of Canberra, A. C. T., Australia. Mr. Herald's charts for this eclipse appear on the next three pages.

For locations in the central path of a solar eclipse, predicted times of second and third contacts are computed on the assumption that the Moon is a smooth circular body. However, in the strict sense this is not true, and, in particular, the irregular limb of the Moon introduces a change into those predicted contact times which may potentially amount to several seconds at locations well away from the central line. The change is caused by two different effects of the irregular limb.

First, the position and motion of the Moon are calculated from gravitational theory which deals only with a point mass, or center of gravity. However, the observed eclipse phenomena are caused by the apparent figure, and the Moon is such an irregular body that the centers of figure and mass do not coincide. Therefore, in predicting the contacts, corrections have been applied to the lunar ephemeris for the offset of the center of figure from the center of mass (or motion), and a mean lunar profile radius, *k*, has been used in the calculations. (See *Elements of the Eclipse.*)

The predicted second and third contacts are defined as the instants at which the solar limb is tangential to the mean lunar limb, but does not intersect it at any point. However, applying this definition to the irregular true lunar limb, one can see by inspection of the profile (page 38) that for any given point of predicted contact on the smooth mean limb, there is some irregular valley feature in the vicinity whose innermost (deepest) point will define the true contact. Then the operational definition of the second and third contacts is whether or not any light from the photosphere is visible. In general, but not always, second contact will be later than predicted, and third contact earlier.

The plot of the lunar limb shows the difference between the true limb and the mean limb exaggerated 70 to 1 on the radial scale. If the solar limb relative to the mean lunar limb is plotted using the same exaggerated radial scale, at the time of predicted second or third contact, it forms an epicyclic curve separating from the lunar limb rapidly with position angle away from the predicted contact point. Furthermore, if this epicyclic curve representing the solar limb is plotted for a sequence of times at small intervals, the sequence of curves progresses essentially along the radial direction from the mean limb at the contact point. Hence, in effect, when this epicyclic curve is shifted radially so as to be tangent to the true irregular limb at some valley point which may lie well off the cited radius, the displacement of the solar limb from the predicted contact point, in seconds of arc, is ascertained for that position angle. The locus of such displacements for all position angles is a curve representing the displacement of the solar limb from the mean lunar limb at the true time it contacts the true lunar limb at any given position angle of contact. In other words, it is the operational lunar limb for predicting contact times.

To use this displacement curve to correct predicted contact times for the mean limb, it is necessary to relate the displacement in seconds of arc to a time interval. This is most conveniently achieved by plotting along with the displacement curve already described another curve representing the locus of the displacement of the solar limb at each position angle at some specified constant time interval (e.g. 10 seconds) from the mean-limb contact time. The ratio of the displacement of the solar limb at true contact to the displacement in a constant time interval then gives directly the correction to be applied to account for the effect of the lunar limb features.

The first curve, for displacement from predicted contact, is nearly the same for the entire eclipse track, but the curve for displacement of the solar limb in 10 seconds is location-dependent and should be calculated for each major observing region in the path.

Overleaf is a pair of correction diagrams for Hawaii; subsequent pages provide similar diagrams for Mexico and Colombia. They are oriented to match the limb profile diagram, so that north is up and east is left. Conceptually, time flows left to right. The left-hand diagram is for second contact, the right hand one is for third contact. The vertical line in each diagram represents the instant of the mean, smooth-limb, predicted contact. The smooth curved lines represent the relative displacement of the solar limb in 10 seconds. Position angles are marked on the vertical. The irregular curves running vertically represent the displacement at the instant of contact with the true, irregular limb, i.e., the operational lunar limb.

To get the correction for a specific location, first obtain the predicted times and position angles of the second and third contacts, either from the tables or by estimation as described elsewhere. On the vertical lines, find each position angle and lay a ruler from from that point to the associated point on the smooth solar limb displacement curve. Measure the distance between those two points, and the distance from the vertical line to the irregular displacement curve. Divide the second measure by the first and multiply by 10 to get the correction in seconds of time. For second contact, if the two curve points are on the same side of the vertical line, add the correction to the predicted time; otherwise, subtract. For third contact, if the two curve points are on the same side of the vertical line, subtract the correction from the predicted contact time; otherwise, add it.

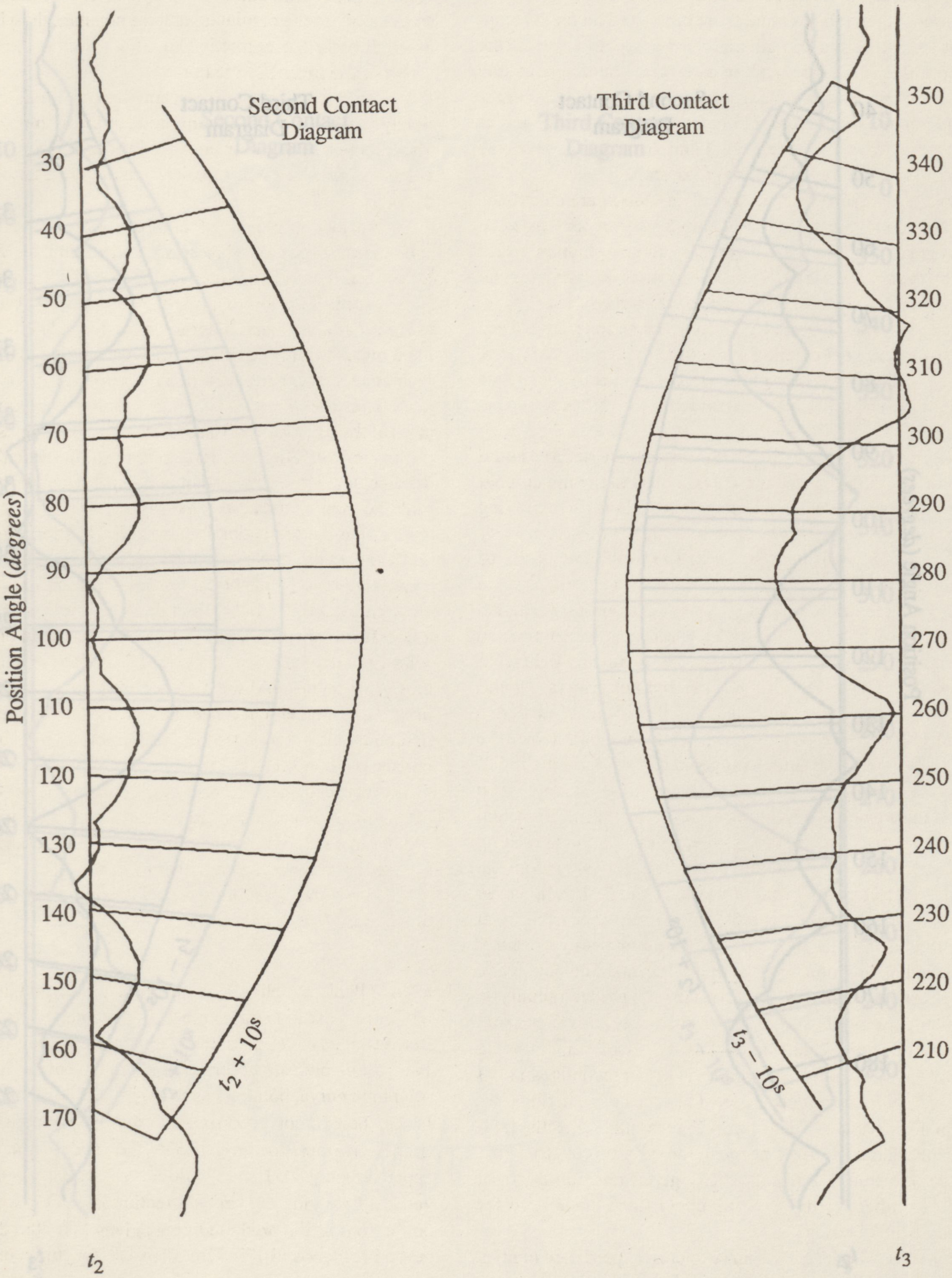
During the time interval between predicted and corrected times, Baily's Bead effects may appear.

EXAMPLE: At Hilo, Hawaii, from the Local Circumstances table, the position angles are 108° (second contact) and 263° (third contact). On the second contact (left) diagram, for angle 108°, the displacement curve lies about 7/63 of the distance to the solar limb curve, both curves on the same side of the vertical line; hence, the time correction is $+1^{s}.1$ Similarly, on the third contact (right) diagram, for angle 263°, the ratio of the distances is approximately 9/63 with both curves on the same side of the vertical line; thus, the time correction is $-1^{s}.4$. Applying these corrections to the predicted times gives 17h 28m 28.0s UT for second contact and 17h 32m 32.9s UT for third contact.

LUNAR PROFILE CORRECTION DIAGRAMS

Hawaii: East Longitude –155° 00′, Latitude +20° 00′

David Herald
P. O. Box 254
Woden, A. C. T. 2606
AUSTRALIA



LUNAR PROFILE CORRECTION DIAGRAMS

Mexico: East Longitude –105° 30′ Latitude +22° 08′

David Herald
P. O. Box 254
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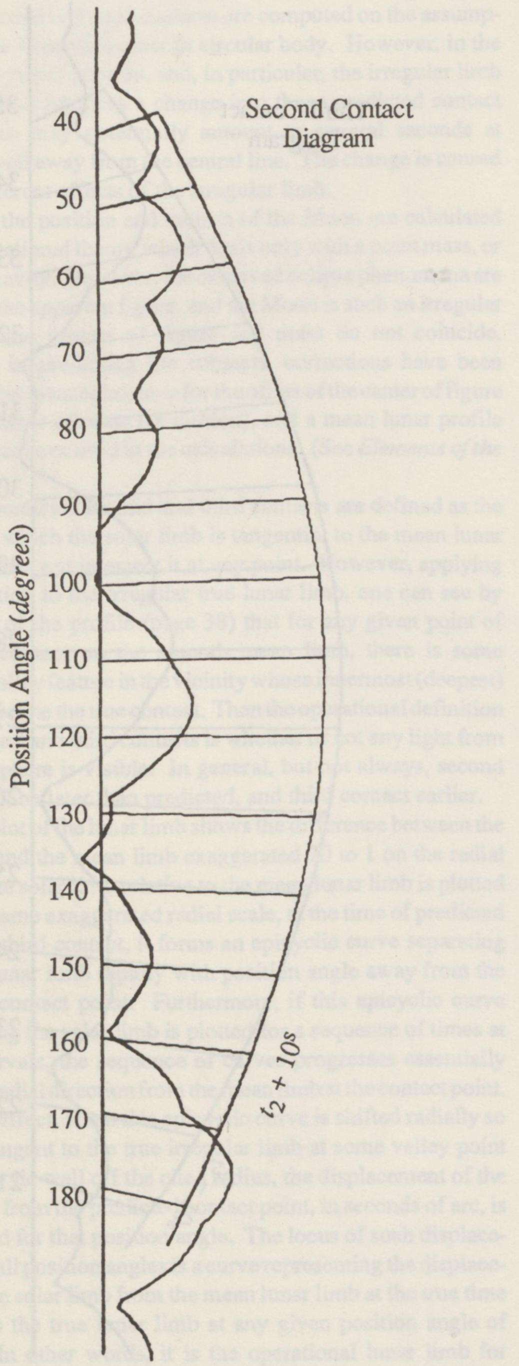
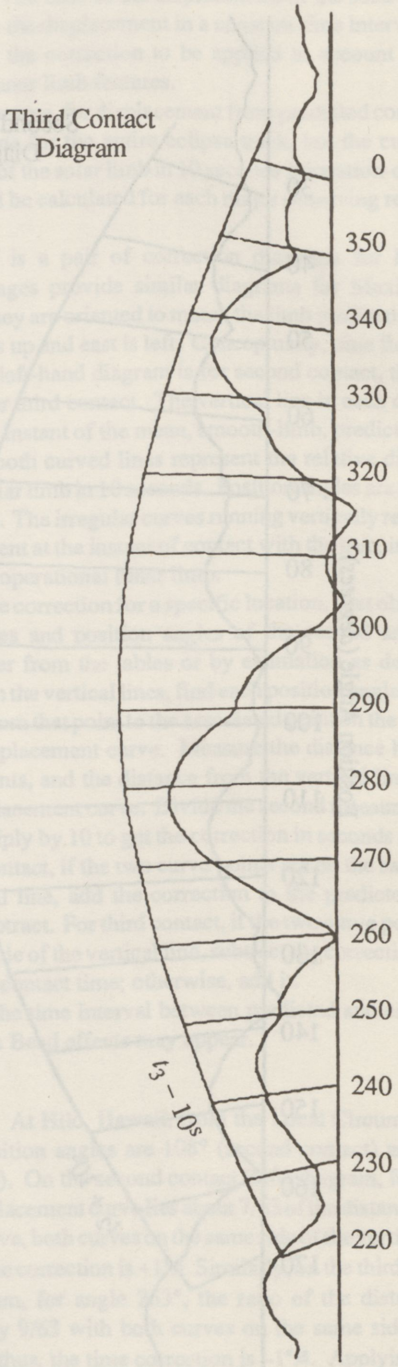
AUSTRALIA

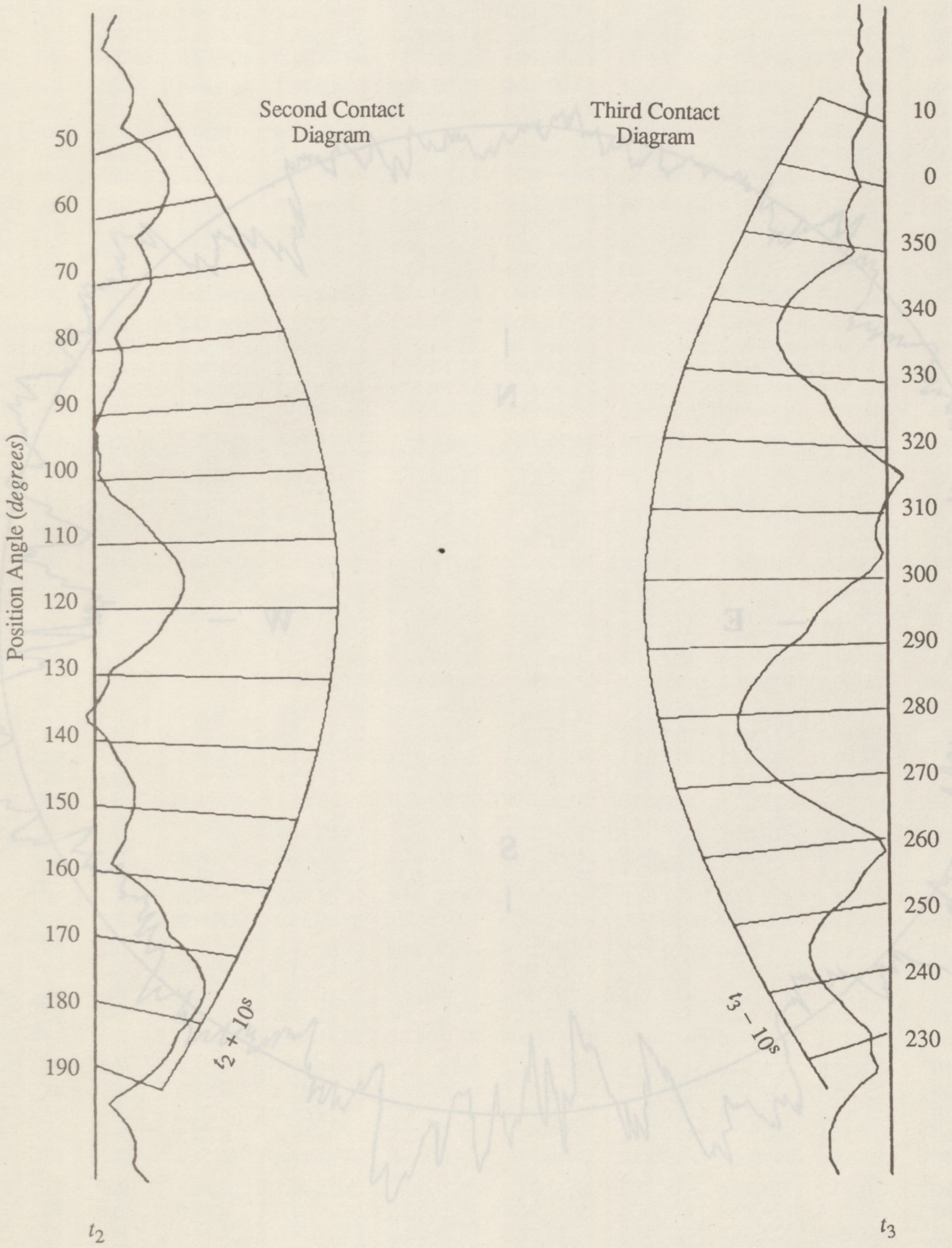




LUNAR PROFILE CORRECTION DIAGRAMS

Colombia: East Longitude –76° 32′, Latitude +3° 57′

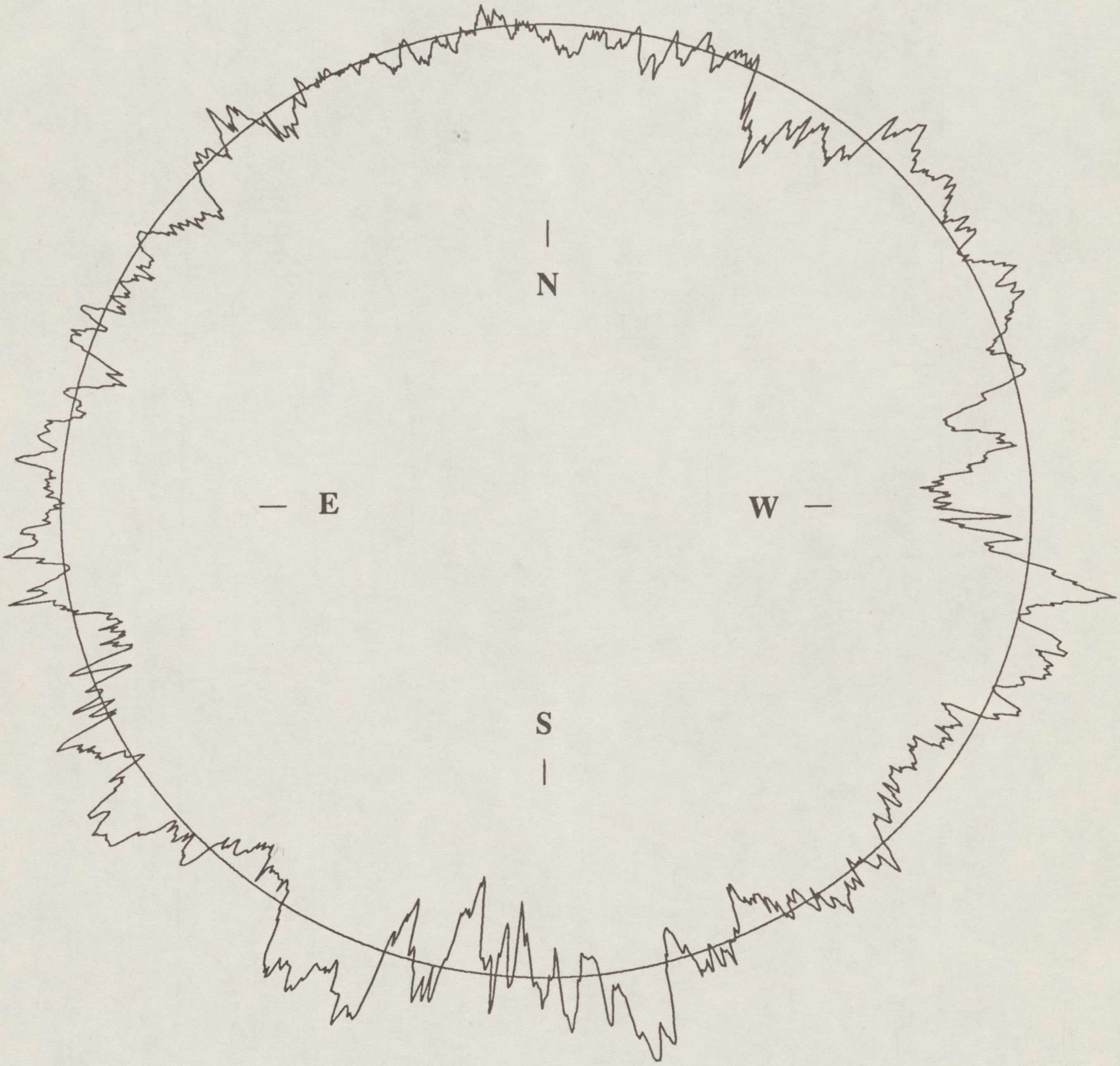
David Herald
P. O. Box 254
Woden, A. C. T. 2606
AUSTRALIA



LUNAR LIMB PROFILE

Radial Scale at Limb: approx. 4 arcsec/inch

true limb: *irregular curve*
mean limb: *smooth curve*



NOTES

SURFACE PATH OF THE TOTAL PHASE OVER LAND

	Latitude of:			Universal Time at:			On Central Line			
Longitude	Northern Limit	Central Line	Southern Limit	Northern Limit	Central Line	Southern Limit	Maximum Duration	Path Width	Sun's Alt.	Az.
° ′	° ′	° ′	° ′	h m s	h m s	h m s	m s	km	°	°
–160 00	+19 16.8	+18 12.2	+17 08.1	17 27 47.7	17 27 17.2	17 26 49.4	3 56.4	222	16	71
–159 30	+19 27.8	+18 23.1	+17 18.9	17 28 05.4	17 27 34.6	17 27 06.4	3 58.1	222	17	72
–159 00	+19 38.7	+18 34.0	+17 29.6	17 28 23.8	17 27 52.7	17 27 24.1	3 59.8	223	17	72
–158 30	+19 49.5	+18 44.7	+17 40.3	17 28 42.9	17 28 11.4	17 27 42.5	4 01.5	223	18	72
–158 00	+20 00.3	+18 55.4	+17 50.8	17 29 02.5	17 28 30.7	17 28 01.5	4 03.2	224	18	72
–157 30	+20 11.0	+19 06.0	+18 01.3	17 29 22.8	17 28 50.7	17 28 21.1	4 04.9	224	19	72
–157 00	+20 21.6	+19 16.5	+18 11.7	17 29 43.8	17 29 11.3	17 28 41.4	4 06.7	225	20	73
–156 30	+20 32.0	+19 26.9	+18 22.0	17 30 05.4	17 29 32.5	17 29 02.4	4 08.4	225	20	73
–156 00	+20 42.4	+19 37.2	+18 32.3	17 30 27.6	17 29 54.5	17 29 24.0	4 10.2	226	21	73
–155 30	+20 52.8	+19 47.4	+18 42.4	17 30 50.4	17 30 17.0	17 29 46.3	4 12.0	226	21	73
–155 00	+21 03.0	+19 57.5	+18 52.5	17 31 13.9	17 30 40.3	17 30 09.3	4 13.8	227	22	73
–154 30	+21 13.1	+20 07.6	+19 02.4	17 31 38.0	17 31 04.2	17 30 32.9	4 15.6	227	22	74
–154 00	+21 23.1	+20 17.5	+19 12.3	17 32 02.8	17 31 28.7	17 30 57.3	4 17.4	228	23	74
–153 30	+21 33.0	+20 27.3	+19 22.0	17 32 28.3	17 31 53.9	17 31 22.2	4 19.3	228	24	74
–153 00	+21 42.8	+20 37.1	+19 31.7	17 32 54.3	17 32 19.8	17 31 47.9	4 21.1	229	24	74
–152 30	+21 52.5	+20 46.7	+19 41.2	17 33 21.0	17 32 46.3	17 32 14.3	4 23.0	229	25	74
–152 00	+22 02.1	+20 56.2	+19 50.7	17 33 48.4	17 33 13.6	17 32 41.3	4 24.9	230	25	75
–151 30	+22 11.5	+21 05.6	+19 60.0	17 34 16.4	17 33 41.4	17 33 09.1	4 26.8	230	26	75
–151 00	+22 20.9	+21 14.9	+20 09.2	17 34 45.1	17 34 10.0	17 33 37.5	4 28.7	231	27	75
–150 30	+22 30.1	+21 24.1	+20 18.3	17 35 14.4	17 34 39.2	17 34 06.6	4 30.6	231	27	75
–150 00	+22 39.3	+21 33.1	+20 27.3	17 35 44.4	17 35 09.1	17 34 36.4	4 32.6	232	28	76
–115 00	+26 00.5	+24 49.1	+23 37.5	18 37 48.0	18 38 27.6	18 39 10.0	6 48.5	259	74	97
–114 30	+25 55.1	+24 43.4	+23 31.6	18 39 04.5	18 39 46.3	18 40 31.1	6 49.6	259	75	97
–114 00	+25 49.3	+24 37.4	+23 25.4	18 40 21.5	18 41 05.8	18 41 52.9	6 50.7	259	76	97
–113 30	+25 43.2	+24 31.1	+23 18.9	18 41 39.2	18 42 25.8	18 43 15.5	6 51.7	260	77	98
–113 00	+25 36.9	+24 24.5	+23 12.1	18 42 57.5	18 43 46.6	18 44 38.6	6 52.6	260	77	98
–112 30	+25 30.2	+24 17.6	+23 04.9	18 44 16.5	18 45 08.0	18 46 02.5	6 53.4	260	78	98
–112 00	+25 23.2	+24 10.4	+22 57.4	18 45 36.1	18 46 30.0	18 47 27.0	6 54.2	260	79	99
–111 30	+25 15.9	+24 02.9	+22 49.6	18 46 56.3	18 47 52.7	18 48 52.1	6 54.9	260	80	99
–111 00	+25 08.3	+23 55.0	+22 41.5	18 48 17.1	18 49 16.0	18 50 17.9	6 55.6	260	81	99
–110 30	+25 00.4	+23 46.8	+22 33.1	18 49 38.5	18 50 39.9	18 51 44.3	6 56.2	260	81	99
–110 00	+24 52.1	+23 38.3	+22 24.3	18 51 00.6	18 52 04.4	18 53 11.3	6 56.7	260	82	100
–109 30	+24 43.5	+23 29.5	+22 15.2	18 52 23.2	18 53 29.5	18 54 38.9	6 57.1	261	83	100
–109 00	+24 34.7	+23 20.3	+22 05.7	18 53 46.4	18 54 55.2	18 56 07.0	6 57.5	261	84	100
–108 30	+24 25.4	+23 10.8	+21 55.9	18 55 10.2	18 56 21.5	18 57 35.8	6 57.8	261	85	100
–108 00	+24 15.9	+23 00.9	+21 45.8	18 56 34.5	18 57 48.3	18 59 05.1	6 58.0	261	85	100
–107 30	+24 06.0	+22 50.8	+21 35.3	18 57 59.4	18 59 15.6	19 00 34.9	6 58.1	261	86	101
–107 00	+23 55.8	+22 40.3	+21 24.5	18 59 24.8	19 00 43.5	19 02 05.2	6 58.1	261	87	100
–106 30	+23 45.3	+22 29.4	+21 13.3	19 00 50.8	19 02 11.9	19 03 36.0	6 58.1	261	88	100
–106 00	+23 34.4	+22 18.2	+21 01.8	19 02 17.3	19 03 40.8	19 05 07.3	6 58.0	261	89	99
–105 30	+23 23.2	+22 06.7	+20 50.0	19 03 44.2	19 05 10.2	19 06 39.0	6 57.8	261	89	93
–105 00	+23 11.6	+21 54.8	+20 37.8	19 05 11.7	19 06 40.0	19 08 11.2	6 57.5	261	90	300
–104 30	+22 59.7	+21 42.6	+20 25.3	19 06 39.6	19 08 10.3	19 09 43.7	6 57.2	261	89	290
–104 00	+22 47.5	+21 30.1	+20 12.4	19 08 07.9	19 09 40.9	19 11 16.6	6 56.7	261	88	288
–103 30	+22 35.0	+21 17.2	+19 59.2	19 09 36.7	19 11 12.0	19 12 49.8	6 56.2	261	87	287
–103 00	+22 22.1	+21 04.0	+19 45.7	19 11 05.9	19 12 43.4	19 14 23.3	6 55.6	261	86	287
–102 30	+22 08.8	+20 50.4	+19 31.8	19 12 35.4	19 14 15.1	19 15 57.1	6 54.9	261	85	287
–102 00	+21 55.3	+20 36.5	+19 17.5	19 14 05.3	19 15 47.1	19 17 31.2	6 54.1	261	85	287
–101 30	+21 41.4	+20 22.3	+19 03.0	19 15 35.5	19 17 19.4	19 19 05.4	6 53.2	261	84	287
–101 00	+21 27.1	+20 07.7	+18 48.1	19 17 06.0	19 18 51.9	19 20 39.9	6 52.3	260	83	287
–100 30	+21 12.6	+19 52.8	+18 32.9	19 18 36.8	19 20 24.6	19 22 14.4	6 51.2	260	82	288
–100 00	+20 57.7	+19 37.6	+18 17.3	19 20 07.8	19 21 57.5	19 23 49.1	6 50.1	260	81	288
– 99 30	+20 42.4	+19 22.0	+18 01.5	19 21 39.1	19 23 30.6	19 25 23.8	6 48.9	260	80	288
– 99 00	+20 26.9	+19 06.2	+17 45.3	19 23 10.5	19 25 03.7	19 26 58.5	6 47.6	260	79	288
– 98 30	+20 11.0	+18 50.0	+17 28.8	19 24 42.0	19 26 36.9	19 28 33.1	6 46.3	260	78	288
– 98 00	+19 54.8	+18 33.5	+17 12.0	19 26 13.6	19 28 10.1	19 30 07.7	6 44.8	260	78	289

SURFACE PATH OF THE TOTAL PHASE OVER LAND

Longitude	Latitude of:			Universal Time at:			On Central Line			
	Northern Limit	Central Line	Southern Limit	Northern Limit	Central Line	Southern Limit	Maximum Duration	Path Width	Sun's Alt.	Sun's Az.
° ′	° ′	° ′	° ′	h m s	h m s	h m s	m s	km	°	°
– 97 30	+19 38.3	+18 16.7	+16 55.0	19 27 45.3	19 29 43.3	19 31 42.2	6 43.3	259	77	289
– 97 00	+19 21.5	+17 59.6	+16 37.6	19 29 17.0	19 31 16.4	19 33 16.5	6 41.7	259	76	289
– 96 30	+19 04.4	+17 42.2	+16 19.9	19 30 48.7	19 32 49.4	19 34 50.6	6 40.0	259	75	289
– 96 00	+18 47.0	+17 24.5	+16 02.0	19 32 20.4	19 34 22.2	19 36 24.5	6 38.3	259	74	290
– 95 30	+18 29.3	+17 06.6	+15 43.8	19 33 51.9	19 35 54.8	19 37 58.0	6 36.5	259	73	290
– 95 00	+18 11.3	+16 48.3	+15 25.3	19 35 23.3	19 37 27.2	19 39 31.2	6 34.6	259	72	290
– 94 30	+17 53.1	+16 29.8	+15 06.6	19 36 54.5	19 38 59.3	19 41 04.0	6 32.7	258	71	290
– 94 00	+17 34.6	+16 11.1	+14 47.6	19 38 25.5	19 40 31.1	19 42 36.3	6 30.7	258	70	291
– 93 30	+17 15.8	+15 52.1	+14 28.4	19 39 56.2	19 42 02.4	19 44 08.1	6 28.6	258	70	291
– 93 00	+16 56.8	+15 32.8	+14 09.0	19 41 26.5	19 43 33.4	19 45 39.4	6 26.5	258	69	291
– 92 30	+16 37.5	+15 13.3	+13 49.4	19 42 56.5	19 45 03.8	19 47 10.1	6 24.4	257	68	291
– 92 00	+16 18.0	+14 53.7	+13 29.5	19 44 26.1	19 46 33.7	19 48 40.1	6 22.1	257	67	292
– 91 30	+15 58.2	+14 33.8	+13 09.5	19 45 55.2	19 48 03.0	19 50 09.4	6 19.9	257	66	292
– 91 00	+15 38.3	+14 13.7	+12 49.3	19 47 23.8	19 49 31.7	19 51 38.0	6 17.6	257	65	292
– 90 30	+15 18.1	+13 53.4	+12 28.9	19 48 51.8	19 50 59.7	19 53 05.8	6 15.2	256	64	292
– 90 00	+14 57.8	+13 32.9	+12 08.4	19 50 19.2	19 52 27.0	19 54 32.8	6 12.8	256	63	292
– 89 30	+14 37.2	+13 12.3	+11 47.7	19 51 45.9	19 53 53.6	19 55 59.0	6 10.4	256	62	293
– 89 00	+14 16.5	+12 51.5	+11 26.9	19 53 12.0	19 55 19.3	19 57 24.2	6 07.9	255	61	293
– 88 30	+13 55.7	+12 30.6	+11 05.9	19 54 37.3	19 56 44.2	19 58 48.4	6 05.4	255	60	293
– 88 00	+13 34.7	+12 09.6	+10 44.9	19 56 01.8	19 58 08.2	20 00 11.7	6 02.8	255	60	293
– 87 30	+13 13.5	+11 48.4	+10 23.7	19 57 25.4	19 59 31.2	20 01 34.0	6 00.3	254	59	293
– 87 00	+12 52.2	+11 27.1	+10 02.5	19 58 48.2	20 00 53.3	20 02 55.2	5 57.7	254	58	293
– 86 30	+12 30.8	+11 05.7	+ 9 41.2	20 00 10.1	20 02 14.4	20 04 15.3	5 55.1	254	57	294
– 86 00	+12 09.3	+10 44.3	+ 9 19.8	20 01 31.1	20 03 34.4	20 05 34.2	5 52.5	253	56	294
– 85 30	+11 47.8	+10 22.8	+ 8 58.3	20 02 51.0	20 04 53.4	20 06 52.1	5 49.9	253	55	294
– 85 00	+11 26.1	+10 01.2	+ 8 36.9	20 04 09.9	20 06 11.3	20 08 08.7	5 47.2	252	54	294
– 84 30	+11 04.4	+ 9 39.5	+ 8 15.3	20 05 27.8	20 07 28.0	20 09 24.2	5 44.6	252	53	294
– 84 00	+10 42.6	+ 9 17.9	+ 7 53.8	20 06 44.6	20 08 43.6	20 10 38.4	5 41.9	252	52	294
– 83 30	+10 20.8	+ 8 56.2	+ 7 32.3	20 08 00.3	20 09 57.9	20 11 51.4	5 39.2	251	52	294
– 83 00	+ 9 58.9	+ 8 34.5	+ 7 10.7	20 09 14.8	20 11 11.1	20 13 03.1	5 36.6	251	51	295
– 82 30	+ 9 37.0	+ 8 12.7	+ 6 49.2	20 10 28.1	20 12 23.1	20 14 13.5	5 33.9	250	50	295
– 82 00	+ 9 15.1	+ 7 51.0	+ 6 27.7	20 11 40.3	20 13 33.8	20 15 22.7	5 31.2	250	49	295
– 81 30	+ 8 53.2	+ 7 29.3	+ 6 06.2	20 12 51.3	20 14 43.2	20 16 30.5	5 28.6	249	48	295
– 81 00	+ 8 31.3	+ 7 07.6	+ 5 44.7	20 14 01.0	20 15 51.4	20 17 37.0	5 25.9	249	47	295
– 80 30	+ 8 09.4	+ 6 46.0	+ 5 23.3	20 15 09.5	20 16 58.3	20 18 42.2	5 23.3	248	46	295
– 80 00	+ 7 47.6	+ 6 24.4	+ 5 02.0	20 16 16.7	20 18 03.8	20 19 46.1	5 20.6	248	46	295
– 79 30	+ 7 25.8	+ 6 02.8	+ 4 40.7	20 17 22.7	20 19 08.1	20 20 48.6	5 18.0	247	45	295
– 79 00	+ 7 04.0	+ 5 41.3	+ 4 19.4	20 18 27.3	20 20 11.1	20 21 49.9	5 15.4	247	44	295
– 78 30	+ 6 42.3	+ 5 19.9	+ 3 58.3	20 19 30.7	20 21 12.7	20 22 49.7	5 12.8	246	43	295
– 78 00	+ 6 20.7	+ 4 58.5	+ 3 37.2	20 20 32.8	20 22 13.0	20 23 48.3	5 10.2	246	42	296
– 77 30	+ 5 59.1	+ 4 37.2	+ 3 16.3	20 21 33.5	20 23 12.0	20 24 45.5	5 07.7	245	41	296
– 77 00	+ 5 37.6	+ 4 16.0	+ 2 55.4	20 22 33.0	20 24 09.7	20 25 41.3	5 05.1	245	41	296
– 76 30	+ 5 16.2	+ 3 54.9	+ 2 34.6	20 23 31.2	20 25 06.1	20 26 35.9	5 02.6	244	40	296
– 76 00	+ 4 54.9	+ 3 33.9	+ 2 13.9	20 24 28.0	20 26 01.1	20 27 29.1	5 00.1	243	39	296
– 75 30	+ 4 33.6	+ 3 13.0	+ 1 53.3	20 25 23.5	20 26 54.8	20 28 21.0	4 57.6	243	38	296
– 75 00	+ 4 12.5	+ 2 52.2	+ 1 32.9	20 26 17.8	20 27 47.2	20 29 11.6	4 55.1	242	37	296
– 74 30	+ 3 51.5	+ 2 31.6	+ 1 12.6	20 27 10.7	20 28 38.4	20 30 01.0	4 52.7	242	37	296
– 74 00	+ 3 30.6	+ 2 11.0	+ 0 52.4	20 28 02.3	20 29 28.2	20 30 49.0	4 50.2	241	36	296
– 73 30	+ 3 09.8	+ 1 50.6	+ 0 32.3	20 28 52.7	20 30 16.7	20 31 35.7	4 47.8	241	35	296
– 73 00	+ 2 49.1	+ 1 30.3	+ 0 12.3	20 29 41.8	20 31 04.0	20 32 21.2	4 45.5	240	34	296
– 72 30	+ 2 28.6	+ 1 10.1	– 0 07.5	20 30 29.6	20 31 50.0	20 33 05.5	4 43.1	239	33	296
– 72 00	+ 2 08.2	+ 0 50.1	– 0 27.1	20 31 16.1	20 32 34.8	20 33 48.5	4 40.8	239	33	296
– 71 30	+ 1 47.9	+ 0 30.1	– 0 46.7	20 32 01.4	20 33 18.3	20 34 30.3	4 38.5	238	32	296
– 71 00	+ 1 27.8	+ 0 10.4	– 1 06.1	20 32 45.4	20 34 00.6	20 35 10.9	4 36.2	237	31	296
– 70 30	+ 1 07.8	– 0 09.2	– 1 25.3	20 33 28.3	20 34 41.7	20 35 50.3	4 34.0	237	30	296

SURFACE PATH OF THE TOTAL PHASE OVER LAND

Longitude	Latitude of: Northern Limit	Latitude of: Central Line	Latitude of: Southern Limit	Universal Time at: Northern Limit	Universal Time at: Central Line	Universal Time at: Southern Limit	On Central Line: Maximum Duration	On Central Line: Path Width	On Central Line: Sun's Alt.	On Central Line: Sun's Az.
° ′	° ′	° ′	° ′	h m s	h m s	h m s	m s	km	°	°
− 70 00	+ 0 47.9	− 0 28.7	− 1 44.4	20 34 09.9	20 35 21.6	20 36 28.5	4 31.8	236	30	296
− 69 30	+ 0 28.2	− 0 48.0	− 2 03.4	20 34 50.3	20 36 00.3	20 37 05.6	4 29.6	235	29	296
− 69 00	+ 0 08.6	− 1 07.2	− 2 22.2	20 35 29.5	20 36 37.8	20 37 41.5	4 27.4	235	28	296
− 68 30	− 0 10.8	− 1 26.2	− 2 40.8	20 36 07.5	20 37 14.2	20 38 16.2	4 25.2	234	27	296
− 68 00	− 0 30.0	− 1 45.1	− 2 59.3	20 36 44.4	20 37 49.4	20 38 49.9	4 23.1	233	27	296
− 67 30	− 0 49.1	− 2 03.8	− 3 17.7	20 37 20.1	20 38 23.6	20 39 22.5	4 21.0	233	26	296
− 67 00	− 1 08.1	− 2 22.4	− 3 35.9	20 37 54.7	20 38 56.6	20 39 54.0	4 19.0	232	25	296
− 66 30	− 1 26.9	− 2 40.8	− 3 53.9	20 38 28.2	20 39 28.5	20 40 24.4	4 16.9	232	25	296
− 66 00	− 1 45.5	− 2 59.1	− 4 11.8	20 39 00.6	20 39 59.4	20 40 53.7	4 14.9	231	24	296
− 65 30	− 2 04.0	− 3 17.2	− 4 29.5	20 39 31.9	20 40 29.1	20 41 22.1	4 12.9	230	23	296
− 65 00	− 2 22.3	− 3 35.1	− 4 47.1	20 40 02.2	20 40 57.9	20 41 49.4	4 11.0	229	23	296
− 64 30	− 2 40.4	− 3 52.9	− 5 04.5	20 40 31.3	20 41 25.6	20 42 15.7	4 09.0	229	22	296
− 64 00	− 2 58.4	− 4 10.5	− 5 21.7	20 40 59.5	20 41 52.4	20 42 41.1	4 07.1	228	21	296
− 63 30	− 3 16.3	− 4 28.0	− 5 38.8	20 41 26.6	20 42 18.1	20 43 05.4	4 05.2	227	21	296
− 63 00	− 3 34.0	− 4 45.3	− 5 55.8	20 41 52.8	20 42 42.8	20 43 28.8	4 03.3	227	20	296
− 62 30	− 3 51.5	− 5 02.4	− 6 12.6	20 42 17.9	20 43 06.6	20 43 51.3	4 01.5	226	19	295
− 62 00	− 4 08.8	− 5 19.4	− 6 29.2	20 42 42.1	20 43 29.5	20 44 12.9	3 59.7	225	19	295
− 61 30	− 4 26.0	− 5 36.2	− 6 45.7	20 43 05.4	20 43 51.4	20 44 33.6	3 57.9	225	18	295
− 61 00	− 4 43.1	− 5 52.9	− 7 02.0	20 43 27.6	20 44 12.4	20 44 53.3	3 56.1	224	17	295
− 60 30	− 4 59.9	− 6 09.4	− 7 18.2	20 43 49.0	20 44 32.5	20 45 12.2	3 54.4	223	17	295
− 60 00	− 5 16.7	− 6 25.8	− 7 34.2	20 44 09.5	20 44 51.7	20 45 30.3	3 52.7	223	16	295
− 59 30	− 5 33.2	− 6 42.0	− 7 50.1	20 44 29.1	20 45 10.1	20 45 47.5	3 51.0	222	15	295
− 59 00	− 5 49.6	− 6 58.0	− 8 05.8	20 44 47.8	20 45 27.6	20 46 03.9	3 49.3	221	15	295
− 58 30	− 6 05.9	− 7 13.9	− 8 21.3	20 45 05.6	20 45 44.3	20 46 19.5	3 47.6	221	14	295
− 58 00	− 6 21.9	− 7 29.7	− 8 36.7	20 45 22.6	20 46 00.2	20 46 34.2	3 46.0	220	13	295
− 57 30	− 6 37.9	− 7 45.3	− 8 52.0	20 45 38.8	20 46 15.2	20 46 48.2	3 44.4	219	13	295
− 57 00	− 6 53.6	− 8 00.7	− 9 07.1	20 45 54.1	20 46 29.5	20 47 01.5	3 42.8	219	12	295
− 56 30	− 7 09.3	− 8 16.0	− 9 22.1	20 46 08.7	20 46 43.0	20 47 14.0	3 41.2	218	12	295
− 56 00	− 7 24.7	− 8 31.1	− 9 36.9	20 46 22.4	20 46 55.7	20 47 25.7	3 39.7	217	11	295
− 55 30	− 7 40.0	− 8 46.1	− 9 51.5	20 46 35.4	20 47 07.7	20 47 36.7	3 38.2	217	10	295
− 55 00	− 7 55.2	− 9 00.9	−10 06.1	20 46 47.7	20 47 18.9	20 47 47.0	3 36.7	216	10	294
− 54 30	− 8 10.2	− 9 15.6	−10 20.4	20 46 59.1	20 47 29.4	20 47 56.6	3 35.2	216	9	294
− 54 00	− 8 25.1	− 9 30.2	−10 34.7	20 47 10.0	20 47 39.4	20 48 05.8	3 33.7	215	9	294
− 53 30	− 8 39.8	− 9 44.6	−10 48.9	20 47 20.0	20 47 48.5	20 48 14.4	3 32.3	214	8	294
− 53 00	− 8 54.3	− 9 58.8	−11 02.8	20 47 29.2	20 47 56.8	20 48 21.8	3 30.9	214	7	294
− 52 30	− 9 08.9	−10 12.7	−11 16.5	20 47 38.6	20 48 03.7	20 48 28.3	3 29.5	213	7	294
− 52 00	− 9 23.2	−10 26.5	−11 29.8	20 47 46.7	20 48 09.9	20 48 33.0	3 28.1	212	6	294
− 51 30	− 9 37.2	−10 40.2	−11 43.0	20 47 53.7	20 48 16.2	20 48 37.2	3 26.7	212	6	294
− 51 00	− 9 51.1	−10 54.0	−11 56.2	20 47 59.8	20 48 22.4	20 48 41.5	3 25.4	211	5	294
− 50 30	−10 04.4	−11 07.8	−12 09.4	20 48 03.8	20 48 28.7	20 48 45.7	3 24.0	210	5	294
− 50 00	−10 17.8	.. .. .	−12 22.6	20 48 07.7	.. ..	20 48 49.9	. .. .	...	.	...
− 49 30	−10 31.2	.. .. .	−12 35.8	20 48 11.7	.. ..	20 48 54.1	. .. .	...	.	...
− 49 00	−10 44.5	.. .. .	−12 49.0	20 48 15.6	.. ..	20 48 58.3	. .. .	...	.	...
− 48 30	−10 57.9	.. .. .	.. .. .	20 48 19.5	.. ..	.. ..	. .. .	...	.	...
− 48 00	−11 11.2	.. .. .	.. .. .	20 48 23.5	.. ..	.. ..	. .. .	...	.	...
− 47 30	−11 24.6		.. .. .	20 48 27.4		.. ..	. .. .	...	.	...

CORRECTIONS TO U.T. AND LATITUDE FOR ELEVATIONS ABOVE SEA LEVEL

Longitude	Latitude Corr.	U.T. Corr.	Longitude	Latitude Corr.	U.T. Corr.	Longitude	Latitude Corr.	U.T. Corr.
° ′	″	s	° ′	″	s	° ′	″	s
−160 00	−1.510	−0.323	−100 00	−0.306	+0.080	− 75 00	−2.386	+0.335
−159 30	−1.495	−0.324	− 99 30	−0.348	+0.088	− 74 30	−2.398	+0.336
−159 00	−1.479	−0.324	− 99 00	−0.392	+0.096	− 74 00	−2.408	+0.337
−158 30	−1.463	−0.325	− 98 30	−0.437	+0.104	− 73 30	−2.417	+0.338
−158 00	−1.446	−0.325	− 98 00	−0.483	+0.112	− 73 00	−2.424	+0.338
−157 30	−1.430	−0.326	− 97 30	−0.530	+0.120	− 72 30	−2.430	+0.339
−157 00	−1.413	−0.326	− 97 00	−0.579	+0.128	− 72 00	−2.435	+0.339
−156 30	−1.395	−0.326	− 96 30	−0.628	+0.136	− 71 30	−2.438	+0.339
−156 00	−1.377	−0.327	− 96 00	−0.678	+0.144	− 71 00	−2.440	+0.340
−155 30	−1.358	−0.327	− 95 30	−0.730	+0.151	− 70 30	−2.441	+0.340
−155 00	−1.340	−0.327	− 95 00	−0.782	+0.159	− 70 00	−2.441	+0.340
−154 30	−1.321	−0.327	− 94 30	−0.835	+0.166	− 69 30	−2.440	+0.340
−154 00	−1.301	−0.327	− 94 00	−0.888	+0.174	− 69 00	−2.438	+0.340
−153 30	−1.281	−0.327	− 93 30	−0.942	+0.181	− 68 30	−2.435	+0.339
−153 00	−1.261	−0.327	− 93 00	−0.996	+0.188	− 68 00	−2.431	+0.339
−152 30	−1.241	−0.327	− 92 30	−1.050	+0.196	− 67 30	−2.426	+0.339
−152 00	−1.220	−0.327	− 92 00	−1.105	+0.203	− 67 00	−2.420	+0.338
−151 30	−1.199	−0.327	− 91 30	−1.159	+0.209	− 66 30	−2.413	+0.338
−151 00	−1.177	−0.327	− 91 00	−1.214	+0.216	− 66 00	−2.406	+0.337
−150 30	−1.156	−0.327	− 90 30	−1.268	+0.223	− 65 30	−2.397	+0.337
−150 00	−1.134	−0.326	− 90 00	−1.322	+0.229	− 65 00	−2.388	+0.336
−115 00	+0.260	−0.131	− 89 30	−1.375	+0.235	− 64 30	−2.379	+0.335
−114 30	+0.262	−0.125	− 89 00	−1.428	+0.241	− 64 00	−2.368	+0.335
−114 00	+0.262	−0.119	− 88 30	−1.480	+0.247	− 63 30	−2.357	+0.334
−113 30	+0.260	−0.113	− 88 00	−1.532	+0.253	− 63 00	−2.345	+0.333
−113 00	+0.258	−0.107	− 87 30	−1.582	+0.258	− 62 30	−2.333	+0.332
−112 30	+0.255	−0.101	− 87 00	−1.632	+0.264	− 62 00	−2.321	+0.331
−112 00	+0.250	−0.095	− 86 30	−1.680	+0.269	− 61 30	−2.307	+0.330
−111 30	+0.244	−0.089	− 86 00	−1.728	+0.274	− 61 00	−2.293	+0.330
−111 00	+0.236	−0.082	− 85 30	−1.774	+0.279	− 60 30	−2.280	+0.329
−110 30	+0.227	−0.075	− 85 00	−1.819	+0.283	− 60 00	−2.265	+0.328
−110 00	+0.217	−0.069	− 84 30	−1.862	+0.288	− 59 30	−2.250	+0.327
−109 30	+0.205	−0.062	− 84 00	−1.904	+0.292	− 59 00	−2.236	+0.326
−109 00	+0.192	−0.055	− 83 30	−1.945	+0.296	− 58 30	−2.217	+0.324
−108 30	+0.178	−0.048	− 83 00	−1.984	+0.299	− 58 00	−2.206	+0.324
−108 00	+0.162	−0.041	− 82 30	−2.022	+0.303	− 57 30	−2.184	+0.322
−107 30	+0.144	−0.034	− 82 00	−2.058	+0.306	− 57 00	−2.175	+0.322
−107 00	+0.125	−0.027	− 81 30	−2.092	+0.310	− 56 30	−2.149	+0.320
−106 30	+0.105	−0.020	− 81 00	−2.124	+0.313	− 56 00	−2.142	+0.319
−106 00	+0.083	−0.012	− 80 30	−2.155	+0.315	− 55 30	−2.116	+0.318
−105 30	+0.059	−0.005	− 80 00	−2.185	+0.318	− 55 00	−2.091	+0.316
−104 30	+0.007	+0.010	− 79 30	−2.212	+0.320	− 54 30	−2.118	+0.318
−104 00	−0.022	+0.018	− 79 00	−2.238	+0.323	− 54 00	−2.037	+0.312
−103 30	−0.052	+0.026	− 78 30	−2.262	+0.325	− 53 30	−2.018	+0.311
−103 00	−0.084	+0.033	− 78 00	−2.285	+0.327	− 53 00	−2.365	+0.336
−102 30	−0.117	+0.041	− 77 30	−2.306	+0.329	− 52 30	−2.683	+0.360
−102 00	−0.152	+0.049	− 77 00	−2.325	+0.330	− 52 00	−2.789	+0.369
−101 30	−0.188	+0.057	− 76 30	−2.343	+0.332	− 51 30	−2.548	+0.351
−101 00	−0.226	+0.065	− 76 00	−2.359	+0.333	− 51 00	−1.614	+0.283
−100 30	−0.265	+0.073	− 75 30	−2.373	+0.334	− 50 30	−0.679	+0.215

These corrections to latitude and time are to be applied to the corresponding surface data on page 40 to correct for elevation. *The units are seconds of arc or seconds of time per thousand feet.*

Example: Elevation 35000 ft. at longitude −115°.

Lat. corr.: $+0''.260 \times 35 = +9''.1 = +0'.2$

Time corr.: $-0^{s}.131 \times 35 = -4^{s}.6$

Hence, for the longitude −115° tabular entry on page 40, the three latitude values should be shifted north by $0'.2$, and the three times advanced (made earlier) by $4^{s}.6$.

PATH OF CENTRAL LINE AT FLYING ALTITUDES

U.T.	10000 Ft.		40000 Ft.		U.T.	10000 Ft.		40000 Ft.	
	Latitude	Longitude	Latitude	Longitude		Latitude	Longitude	Latitude	Longitude
h m	° ′	° ′	° ′	° ′	h m	° ′	° ′	° ′	° ′
Limits	+12 28.7	−174 35.8	+12 28.7	−174 33.6	18 18	+25 41.4	−123 25.9	+25 41.4	−123 23.1
17 24	+15 08.9	−167 59.2	+15 22.5	−167 22.8	18 19	+25 40.6	−122 59.1	+25 40.6	−122 56.3
17 25	+16 25.0	−164 44.7	+16 33.8	−164 19.7	18 20	+25 39.6	−122 32.6	+25 39.5	−122 29.9
17 26	+17 19.3	−162 22.3	+17 26.1	−162 02.1	18 21	+25 38.4	−122 06.3	+25 38.3	−122 03.6
17 27	+18 02.9	−160 24.8	+18 08.5	−160 07.4	18 22	+25 36.9	−121 40.2	+25 36.9	−121 37.6
17 28	+18 39.9	−158 42.8	+18 44.7	−158 27.3	18 23	+25 35.3	−121 14.3	+25 35.3	−121 11.8
17 29	+19 12.2	−157 11.4	+19 16.4	−156 57.4	18 24	+25 33.6	−120 48.7	+25 33.5	−120 46.3
17 30	+19 41.0	−155 48.1	+19 44.8	−155 35.1	18 25	+25 31.6	−120 23.3	+25 31.5	−120 20.9
17 31	+20 07.0	−154 31.0	+20 10.4	−154 18.9	18 26	+25 29.5	−119 58.1	+25 29.4	−119 55.8
17 32	+20 30.7	−153 19.0	+20 33.8	−153 07.6	18 27	+25 27.2	−119 33.0	+25 27.1	−119 30.8
17 33	+20 52.5	−152 11.2	+20 55.3	−152 00.4	18 28	+25 24.7	−119 08.2	+25 24.6	−119 06.1
17 34	+21 12.6	−151 06.9	+21 15.1	−150 56.7	18 29	+25 22.0	−118 43.6	+25 21.9	−118 41.5
17 35	+21 31.2	−150 05.7	+21 33.6	−149 56.0	18 30	+25 19.2	−118 19.2	+25 19.1	−118 17.2
17 36	+21 48.6	−149 07.2	+21 50.8	−148 57.9	18 31	+25 16.2	−117 54.9	+25 16.1	−117 53.0
17 37	+22 04.8	−148 11.0	+22 06.8	−148 02.1	18 32	+25 13.1	−117 30.9	+25 13.0	−117 29.0
17 38	+22 20.0	−147 17.0	+22 21.9	−147 08.4	18 33	+25 09.8	−117 07.0	+25 09.7	−117 05.1
17 39	+22 34.3	−146 24.8	+22 36.0	−146 16.6	18 34	+25 06.3	−116 43.3	+25 06.2	−116 41.5
17 40	+22 47.7	−145 34.3	+22 49.3	−145 26.4	18 35	+25 02.7	−116 19.7	+25 02.6	−116 18.0
17 41	+23 00.3	−144 45.4	+23 01.8	−144 37.7	18 36	+24 58.9	−115 56.3	+24 58.8	−115 54.7
17 42	+23 12.2	−143 57.9	+23 13.6	−143 50.5	18 37	+24 55.0	−115 33.1	+24 54.9	−115 31.5
17 43	+23 23.4	−143 11.7	+23 24.7	−143 04.5	18 38	+24 50.9	−115 10.0	+24 50.8	−115 08.5
17 44	+23 33.9	−142 26.7	+23 35.1	−142 19.8	18 39	+24 46.7	−114 47.1	+24 46.6	−114 45.6
17 45	+23 43.8	−141 42.9	+23 45.0	−141 36.1	18 40	+24 42.3	−114 24.3	+24 42.2	−114 22.9
17 46	+23 53.2	−141 00.0	+23 54.3	−140 53.5	18 41	+24 37.8	−114 01.7	+24 37.7	−114 00.3
17 47	+24 02.1	−140 18.1	+24 03.1	−140 11.8	18 42	+24 33.1	−113 39.2	+24 33.0	−113 37.9
17 48	+24 10.4	−139 37.2	+24 11.4	−139 31.0	18 43	+24 28.3	−113 16.8	+24 28.2	−113 15.6
17 49	+24 18.3	−138 57.0	+24 19.2	−138 51.0	18 44	+24 23.4	−112 54.6	+24 23.2	−112 53.4
17 50	+24 25.7	−138 17.7	+24 26.5	−138 11.9	18 45	+24 18.3	−112 32.5	+24 18.1	−112 31.4
17 51	+24 32.7	−137 39.2	+24 33.4	−137 33.5	18 46	+24 13.0	−112 10.6	+24 12.9	−112 09.5
17 52	+24 39.2	−137 01.3	+24 39.9	−136 55.7	18 47	+24 07.7	−111 48.7	+24 07.5	−111 47.7
17 53	+24 45.4	−136 24.1	+24 46.0	−136 18.7	18 48	+24 02.1	−111 27.0	+24 02.0	−111 26.1
17 54	+24 51.2	−135 47.6	+24 51.8	−135 42.3	18 49	+23 56.5	−111 05.4	+23 56.4	−111 04.5
17 55	+24 56.6	−135 11.6	+24 57.1	−135 06.5	18 50	+23 50.7	−110 43.9	+23 50.6	−110 43.1
17 56	+25 01.6	−134 36.3	+25 02.1	−134 31.3	18 51	+23 44.8	−110 22.5	+23 44.7	−110 21.8
17 57	+25 06.3	−134 01.5	+25 06.8	−133 56.6	18 52	+23 38.7	−110 01.3	+23 38.6	−110 00.5
17 58	+25 10.7	−133 27.2	+25 11.1	−133 22.5	18 53	+23 32.5	−109 40.1	+23 32.4	−109 39.4
17 59	+25 14.8	−132 53.5	+25 15.1	−132 48.8	18 54	+23 26.2	−109 19.1	+23 26.1	−109 18.4
18 00	+25 18.5	−132 20.2	+25 18.9	−132 15.6	18 55	+23 19.7	−108 58.1	+23 19.6	−108 57.5
18 01	+25 21.9	−131 47.3	+25 22.3	−131 42.9	18 56	+23 13.1	−108 37.2	+23 13.1	−108 36.7
18 02	+25 25.1	−131 15.0	+25 25.4	−131 10.6	18 57	+23 06.4	−108 16.5	+23 06.3	−108 16.0
18 03	+25 28.0	−130 43.0	+25 28.2	−130 38.8	18 58	+22 59.6	−107 55.8	+22 59.5	−107 55.4
18 04	+25 30.6	−130 11.5	+25 30.8	−130 07.4	18 59	+22 52.6	−107 35.2	+22 52.5	−107 34.8
18 05	+25 32.9	−129 40.3	+25 33.1	−129 36.3	19 00	+22 45.5	−107 14.7	+22 45.4	−107 14.4
18 06	+25 34.9	−129 09.6	+25 35.1	−129 05.7	19 01	+22 38.2	−106 54.3	+22 38.2	−106 54.0
18 07	+25 36.8	−128 39.2	+25 36.9	−128 35.4	19 02	+22 30.9	−106 33.9	+22 30.8	−106 33.7
18 08	+25 38.3	−128 09.1	+25 38.5	−128 05.4	19 03	+22 23.4	−106 13.7	+22 23.4	−106 13.5
18 09	+25 39.6	−127 39.4	+25 39.8	−127 35.8	19 04	+22 15.8	−105 53.5	+22 15.8	−105 53.4
18 10	+25 40.7	−127 10.1	+25 40.8	−127 06.5	19 05	+22 08.0	−105 33.4	+22 08.0	−105 33.3
18 11	+25 41.6	−126 41.0	+25 41.7	−126 37.6	19 06	+22 00.1	−105 13.3	+22 00.2	−105 13.3
18 12	+25 42.2	−126 12.3	+25 42.3	−126 08.9	19 07	+21 52.1	−104 53.3	+21 52.2	−104 53.4
18 13	+25 42.6	−125 43.9	+25 42.6	−125 40.6	19 08	+21 44.0	−104 33.4	+21 44.1	−104 33.5
18 14	+25 42.8	−125 15.7	+25 42.8	−125 12.5	19 09	+21 35.8	−104 13.5	+21 35.8	−104 13.7
18 15	+25 42.8	−124 47.9	+25 42.8	−124 44.8	19 10	+21 27.4	−103 53.7	+21 27.5	−103 53.9
18 16	+25 42.5	−124 20.3	+25 42.5	−124 17.3	19 11	+21 18.9	−103 34.0	+21 19.0	−103 34.2
18 17	+25 42.1	−123 53.0	+25 42.1	−123 50.0	19 12	+21 10.3	−103 14.3	+21 10.4	−103 14.6

PATH OF CENTRAL LINE AT FLYING ALTITUDES

U.T.	10000 Ft.		40000 Ft.	
	Latitude	Longitude	Latitude	Longitude
h m	° ′	° ′	° ′	° ′
19 13	+21 01.5	−102 54.6	+21 01.7	−102 55.0
19 14	+20 52.7	−102 35.0	+20 52.8	−102 35.4
19 15	+20 43.7	−102 15.5	+20 43.8	−102 15.9
19 16	+20 34.6	−101 55.9	+20 34.7	−101 56.4
19 17	+20 25.3	−101 36.4	+20 25.5	−101 37.0
19 18	+20 16.0	−101 17.0	+20 16.1	−101 17.6
19 19	+20 06.5	−100 57.6	+20 06.7	−100 58.2
19 20	+19 56.9	−100 38.2	+19 57.1	−100 38.8
19 21	+19 47.1	−100 18.8	+19 47.3	−100 19.5
19 22	+19 37.2	− 99 59.4	+19 37.5	−100 00.2
19 23	+19 27.3	− 99 40.1	+19 27.5	− 99 40.9
19 24	+19 17.1	− 99 20.8	+19 17.4	− 99 21.7
19 25	+19 06.9	− 99 01.5	+19 07.2	− 99 02.4
19 26	+18 56.5	− 98 42.2	+18 56.8	− 98 43.1
19 27	+18 46.0	− 98 22.9	+18 46.4	− 98 23.9
19 28	+18 35.4	− 98 03.6	+18 35.7	− 98 04.6
19 29	+18 24.6	− 97 44.3	+18 25.0	− 97 45.4
19 30	+18 13.8	− 97 25.0	+18 14.1	− 97 26.1
19 31	+18 02.7	− 97 05.7	+18 03.2	− 97 06.9
19 32	+17 51.6	− 96 46.3	+17 52.0	− 96 47.6
19 33	+17 40.3	− 96 27.0	+17 40.8	− 96 28.3
19 34	+17 28.9	− 96 07.6	+17 29.4	− 96 09.0
19 35	+17 17.4	− 95 48.2	+17 17.9	− 95 49.6
19 36	+17 05.7	− 95 28.8	+17 06.2	− 95 30.3
19 37	+16 53.9	− 95 09.3	+16 54.4	− 95 10.8
19 38	+16 41.9	− 94 49.8	+16 42.5	− 94 51.4
19 39	+16 29.9	− 94 30.3	+16 30.5	− 94 31.9
19 40	+16 17.6	− 94 10.7	+16 18.3	− 94 12.4
19 41	+16 05.3	− 93 51.1	+16 05.9	− 93 52.8
19 42	+15 52.8	− 93 31.4	+15 53.4	− 93 33.1
19 43	+15 40.1	− 93 11.6	+15 40.8	− 93 13.4
19 44	+15 27.3	− 92 51.8	+15 28.1	− 92 53.7
19 45	+15 14.4	− 92 31.9	+15 15.1	− 92 33.8
19 46	+15 01.3	− 92 11.9	+15 02.1	− 92 13.9
19 47	+14 48.1	− 91 51.8	+14 48.9	− 91 53.9
19 48	+14 34.7	− 91 31.7	+14 35.5	− 91 33.8
19 49	+14 21.2	− 91 11.4	+14 22.0	− 91 13.6
19 50	+14 07.5	− 90 51.1	+14 08.3	− 90 53.3
19 51	+13 53.6	− 90 30.6	+13 54.5	− 90 32.9
19 52	+13 39.6	− 90 10.1	+13 40.5	− 90 12.4
19 53	+13 25.4	− 89 49.4	+13 26.4	− 89 51.8
19 54	+13 11.1	− 89 28.6	+13 12.1	− 89 31.0
19 55	+12 56.6	− 89 07.6	+12 57.6	− 89 10.1
19 56	+12 41.9	− 88 46.5	+12 42.9	− 88 49.1
19 57	+12 27.0	− 88 25.2	+12 28.1	− 88 27.9
19 58	+12 12.0	− 88 03.8	+12 13.1	− 88 06.5
19 59	+11 56.8	− 87 42.2	+11 57.9	− 87 45.0
20 00	+11 41.4	− 87 20.4	+11 42.6	− 87 23.3
20 01	+11 25.8	− 86 58.5	+11 27.0	− 87 01.4
20 02	+11 10.0	− 86 36.3	+11 11.3	− 86 39.3
20 03	+10 54.0	− 86 13.9	+10 55.3	− 86 17.0
20 04	+10 37.8	− 85 51.3	+10 39.2	− 85 54.5
20 05	+10 21.4	− 85 28.5	+10 22.8	− 85 31.7
20 06	+10 04.8	− 85 05.4	+10 06.2	− 85 08.7
20 07	+ 9 48.0	− 84 42.1	+ 9 49.4	− 84 45.4
20 08	+ 9 30.9	− 84 18.5	+ 9 32.4	− 84 21.9
20 09	+ 9 13.6	− 83 54.6	+ 9 15.2	− 83 58.1
20 10	+ 8 56.1	− 83 30.3	+ 8 57.7	− 83 33.9
20 11	+ 8 38.3	− 83 05.8	+ 8 40.0	− 83 09.5
20 12	+ 8 20.3	− 82 40.9	+ 8 22.0	− 82 44.7
20 13	+ 8 02.0	− 82 15.7	+ 8 03.8	− 82 19.5
20 14	+ 7 43.4	− 81 50.0	+ 7 45.3	− 81 54.0
20 15	+ 7 24.6	− 81 24.0	+ 7 26.5	− 81 28.0
20 16	+ 7 05.5	− 80 57.5	+ 7 07.4	− 81 01.7
20 17	+ 6 46.0	− 80 30.6	+ 6 48.1	− 80 34.9
20 18	+ 6 26.3	− 80 03.2	+ 6 28.4	− 80 07.6
20 19	+ 6 06.2	− 79 35.3	+ 6 08.4	− 79 39.8
20 20	+ 5 45.8	− 79 06.8	+ 5 48.0	− 79 11.4
20 21	+ 5 25.1	− 78 37.8	+ 5 27.3	− 78 42.5
20 22	+ 5 03.9	− 78 08.1	+ 5 06.2	− 78 13.0
20 23	+ 4 42.4	− 77 37.8	+ 4 44.8	− 77 42.8
20 24	+ 4 20.4	− 77 06.8	+ 4 22.9	− 77 11.9
20 25	+ 3 58.0	− 76 35.0	+ 4 00.6	− 76 40.3
20 26	+ 3 35.2	− 76 02.4	+ 3 37.9	− 76 07.9
20 27	+ 3 11.9	− 75 28.9	+ 3 14.6	− 75 34.6
20 28	+ 2 48.0	− 74 54.5	+ 2 50.9	− 75 00.3
20 29	+ 2 23.6	− 74 19.0	+ 2 26.6	− 74 25.1
20 30	+ 1 58.6	− 73 42.5	+ 2 01.7	− 73 48.7
20 31	+ 1 33.0	− 73 04.7	+ 1 36.2	− 73 11.2
20 32	+ 1 06.7	− 72 25.6	+ 1 10.0	− 72 32.3
20 33	+ 0 39.7	− 71 45.0	+ 0 43.1	− 71 52.0
20 34	+ 0 11.8	− 71 02.8	+ 0 15.4	− 71 10.1
20 35	− 0 16.9	− 70 18.8	− 0 13.2	− 70 26.4
20 36	− 0 46.6	− 69 32.8	− 0 42.7	− 69 40.8
20 37	− 1 17.4	− 68 44.5	− 1 13.3	− 68 52.9
20 38	− 1 49.5	− 67 53.7	− 1 45.2	− 68 02.5
20 39	− 2 22.9	− 66 59.9	− 2 18.3	− 67 09.2
20 40	− 2 57.9	− 66 02.6	− 2 53.1	− 66 12.5
20 41	− 3 34.8	− 65 01.2	− 3 29.6	− 65 11.9
20 42	− 4 13.8	− 63 55.0	− 4 08.3	− 64 06.4
20 43	− 4 55.6	− 62 42.6	− 4 49.6	− 62 55.1
20 44	− 5 40.9	− 61 22.4	− 5 34.3	− 61 36.3
20 45	− 6 30.6	− 59 51.9	− 6 23.2	− 60 07.6
20 46	− 7 26.7	− 58 06.4	− 7 18.2	− 58 24.8
20 47	− 8 33.0	− 55 57.0	− 8 22.5	− 56 20.0
20 48	− 9 59.5	− 52 59.1	− 9 44.7	− 53 32.5
20 49	.. .. .	.. .. .	−12 33.6	− 47 15.3
Limits	−12 58.4	− 46 13.3	−12 58.4	− 46 15.5

INDEX TO THE DETAILED PATH MAPS

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Hawaii, USA 48
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The detailed maps which follow are presented on portions of the Defense Mapping Agency's Operational Navigation Charts (ONC), scale 1:1,000,000, Lambert Conformal Conic Projection.

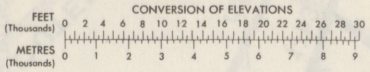
The maps of Hawaii and Baja California have been reduced to 66% of original size, enlarging the scale from 15.78 miles/inch to 23.91 miles/inch. All of the remaining maps have been reduced to 50% of original size, enlarging the scale from 15.78 miles/inch to 31.56 miles/inch.

The heavy solid lines mark the northern and southern limits of the predicted path. Each dashed line represents the projection of the diameter of the umbra, joining the northern and southern limits and central point for the indicated instant, at which all points on the dashed line experience maximum eclipse. The small arrow on each map, located on the central line at a time mark, indicates the azimuth of the Sun at that point. The altitude of the Sun at the point is given in the accompanying label.

For more information, see *Estimating Second and Third Contacts* in the General Information text at the beginning of this *Circular*.

ELEVATIONS IN FEET

CONVERSION OF ELEVATIONS



MAXIMUM TERRAIN ELEVATIONS

Maximum Terrain elevation figures centered in the area bounded by ticked lines of LATITUDE and LONGITUDE, are represented in THOUSANDS and HUNDREDS of feet, BUT DO NOT INCLUDE ELEVATIONS OF VERTICAL OBSTRUCTIONS.

3100 feet 31

ATTENTION

THIS CHART CONTAINS MAXIMUM ELEVATION FIGURES (MEF)

The Maximum Elevation Figures shown in quadrangles bounded by ticked lines of latitude and longitude are represented in THOUSANDS and HUNDREDS of feet above mean sea level. The MEF is based on information available concerning the highest known feature in each quadrangle, including terrain and obstructions, (trees, towers, antennas, etc.).

Example: 12,500 feet........ 12^5

CULTURE

Actual city outline ....
Towns and Villages (outline unknown)............ □ ▫
Landmark features (unillustrated)...................• tower
Dual lane roads
Primary roads
Secondary roads
Single railway
Multiple railway
Power transmission line

VEGETATION

Distinctive vegetation..

AERONAUTICAL INFORMATION

Major aerodromes .... J EDNA 920
Runway pattern and 6000 foot diameter circle is shown at 1:500,000 scale.
Centre of circle represents true position of aerodrome.
Major aerodromes, runway pattern not available .... ○
Minor aerodromes .... ○
Aerodrome landmark Status and Serviceability Unknown........
Marine light with characteristics .... ● Occ WRG
Aeronautical light .... ★
Jet facilities available .... J
Seaplane base ....
Lightship ....

Major aerodromes portrayed have a hard surface runway length of 3000 feet or more. When runway pattern is not shown, number following the name indicates length of longest runway to nearest hundreds of feet. Aerodrome elevations are in feet above sea level.

OBSTRUCTIONS

Vertical obstructions 1850 (1250)
Highest vertical obstruction (above MSL) within ticked lines of latitude and longitude 1850 (1250)
Multiple obstructions ....
Vertical obstructions with landmark significance ....

Numbers adjacent to obstruction indicate elevation of top of obstruction above mean sea level (MSL). Numerals in parenthesis indicate height above ground level (AGL). Vertical obstructions under 200 feet in height (AGL) are not shown.

RADIO AIDS TO NAVIGATION

VHF OMNI RANGE (VOR)
VORTAC
TACAN
VOR with DME
○ Other facilities

SPECIAL USE AIRSPACE

P-16

PROHIBITED AREAS

A-4

ALERT, CAUTION, DANGER
RESTRICTED OR WARNING AREA

NUMBERS INDICATE INTERNATIONALLY
RECOGNIZED NUMERICAL
IDENTIFICATION

BUFFER ZONE

CONTOUR INTERVAL

1000 feet

Intermediate contour shown only at 500 feet

Basic Intermediate

CONTOURS

(Accuracy based on mean sea level)

Contours accurate to within 500 feet ....
Contours accurate to within 1000 feet ......

SPOT ELEVATIONS

(Accuracy based on mean sea level)

Maximum vertical error 100 feet. . . . . •0000
Maximum possible vertical error (None Shown). . . . x0000
Critical elevation . . . . •0000
Lake and stream elevation . . . .

GLOSSARY

Bahía	bay
Bancos	banks
Cabo	cape
Cayo(s)	key(s)
Cerro(s)	mountain(s)
Cordillera	mountain range
Golfo	bay
Isla	island
Lago	lake
Laguna	lagoon, lake
Montaña(s)	mountain(s) range
Península	peninsula
Pico(s)	peak(s)
Punta	point
Río	river
Sierra	mountain range
Volcán	volcano

NOTES

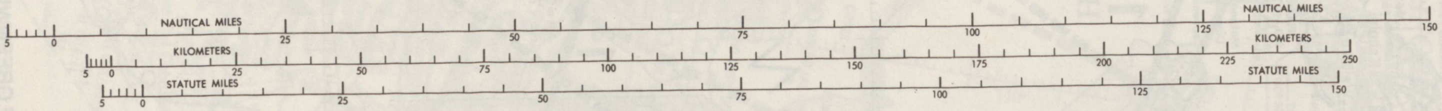
Power transmission line information and obstructions have been extracted from the most reliable source available. However, there is no assurance that all the transmission lines and obstructions are shown or that their location and heights are correct.

The representation of international boundaries is not necessarily authoritative.

Geographic names or their spellings do not necessarily reflect recognition of their political status of and area by the United States Government.

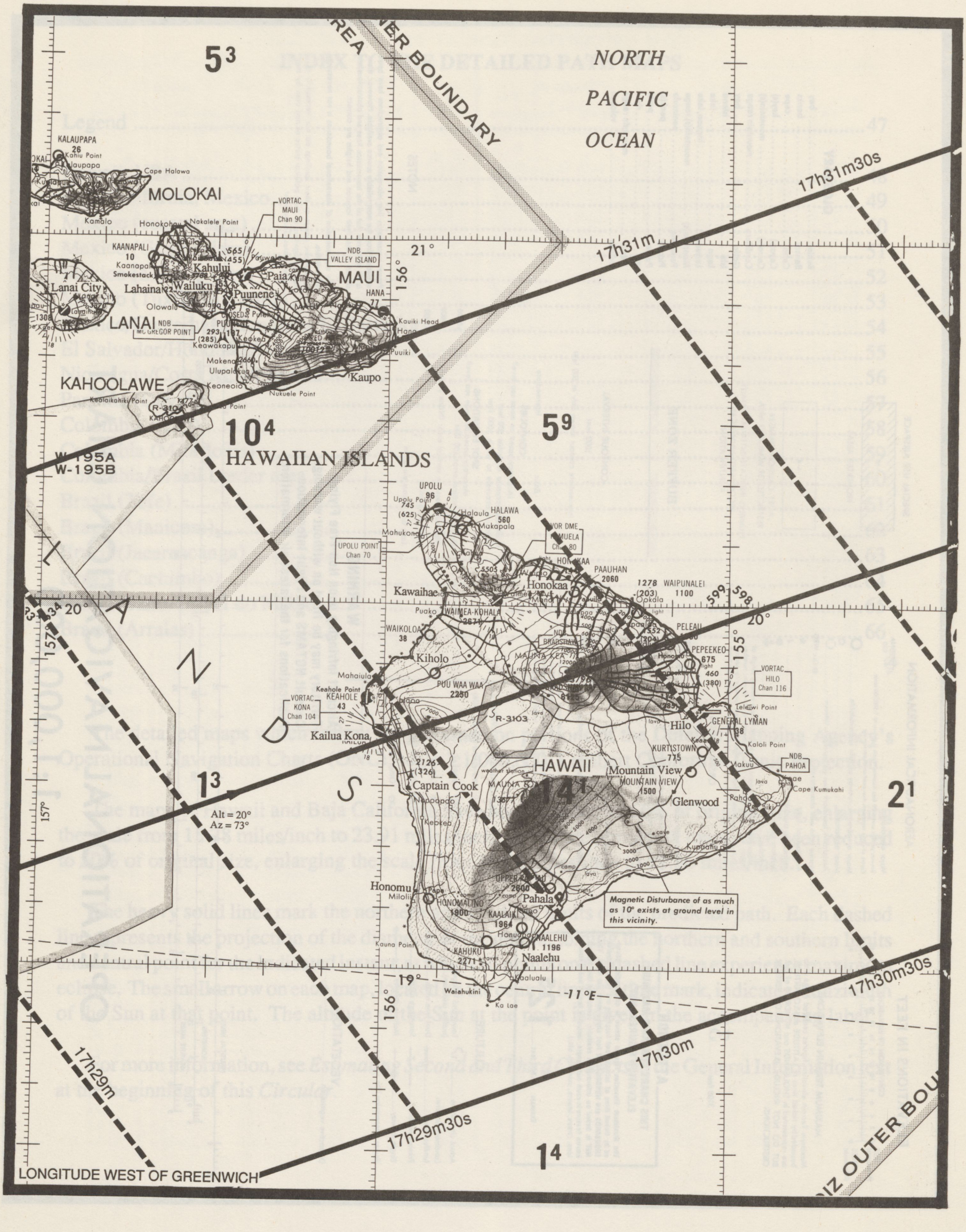
WARNING

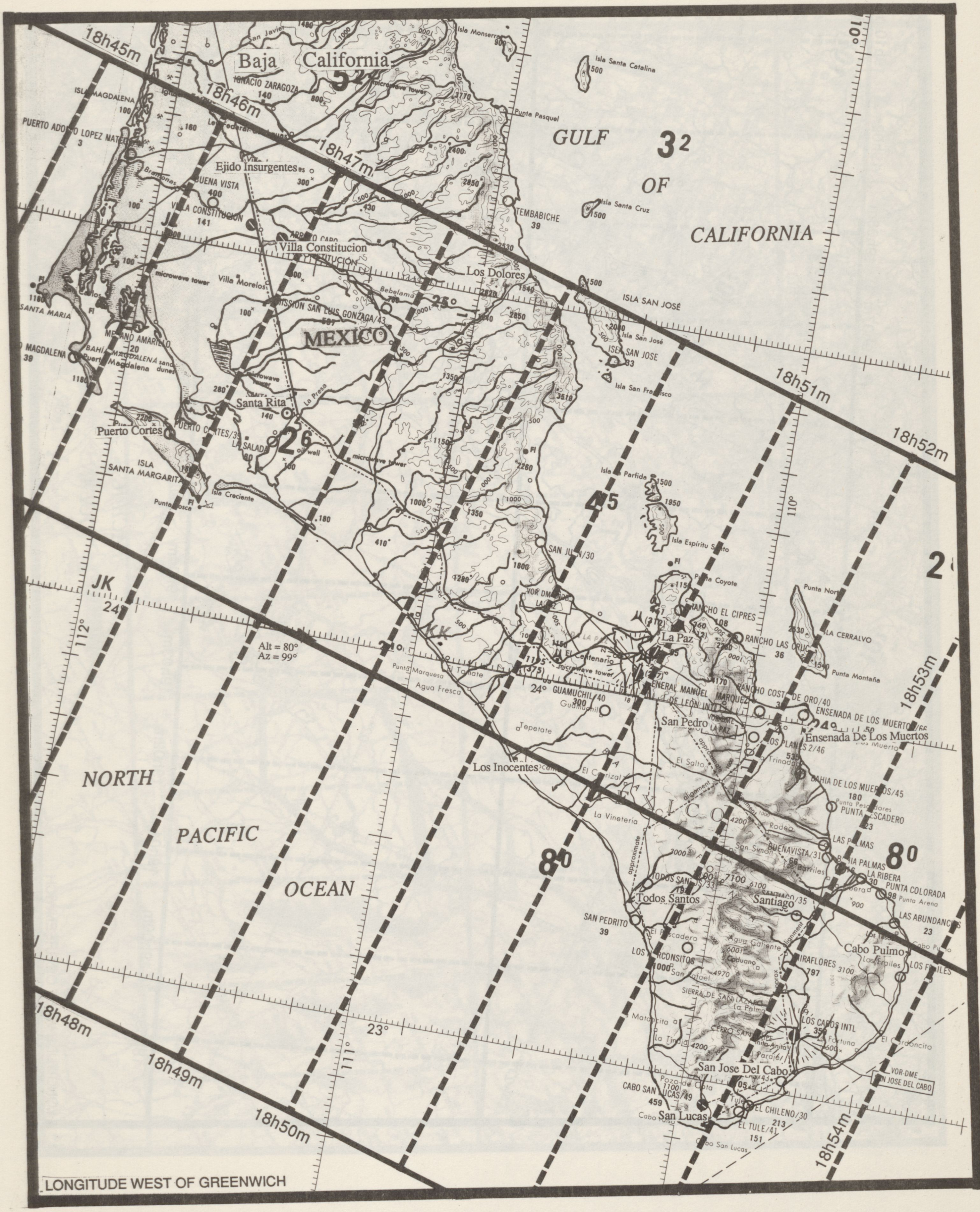
Aircraft infringing upon Non-Free Flying Territory may be fired on without warning. Consult NOTAMS and Flight Information Publications for the latest air information.

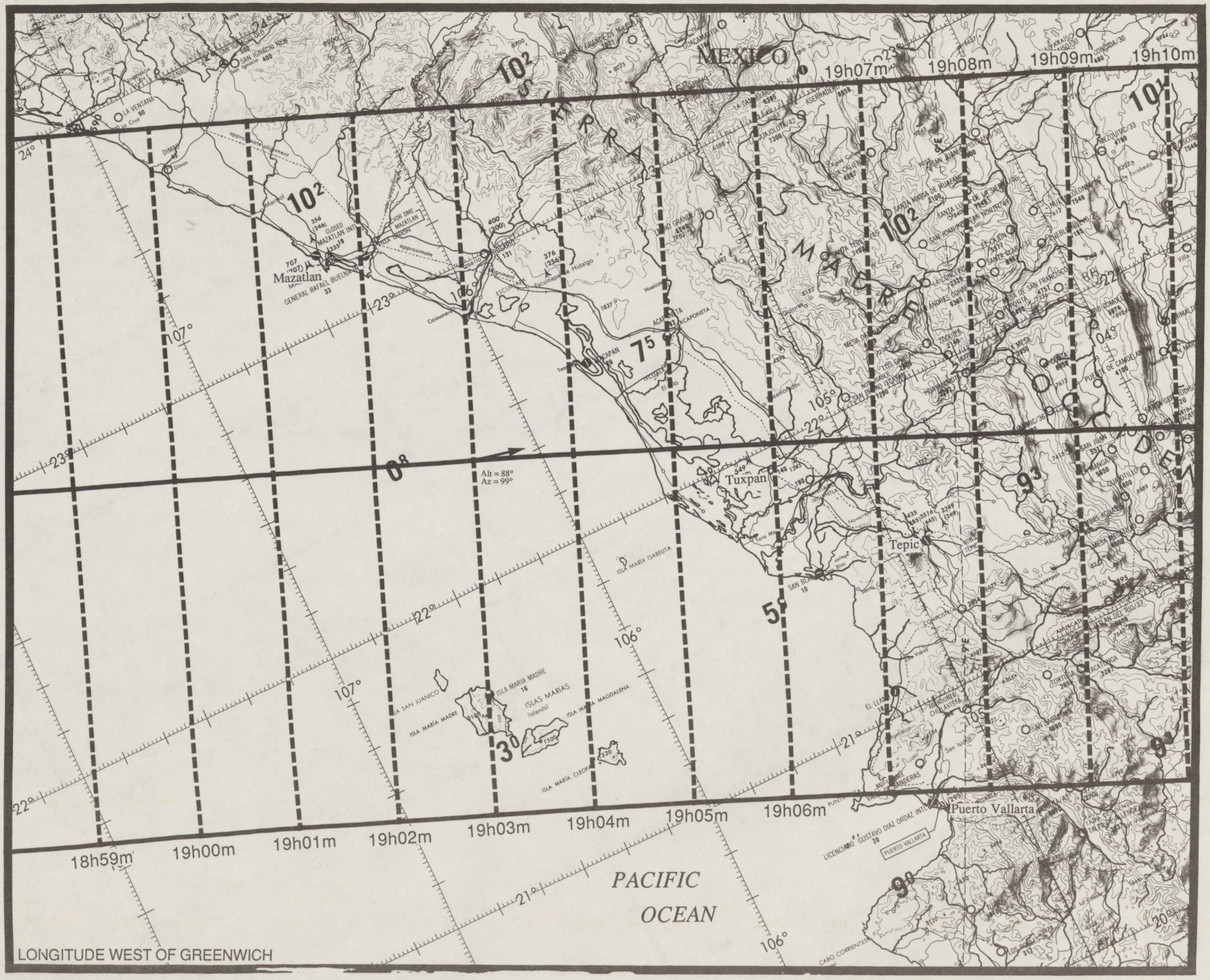


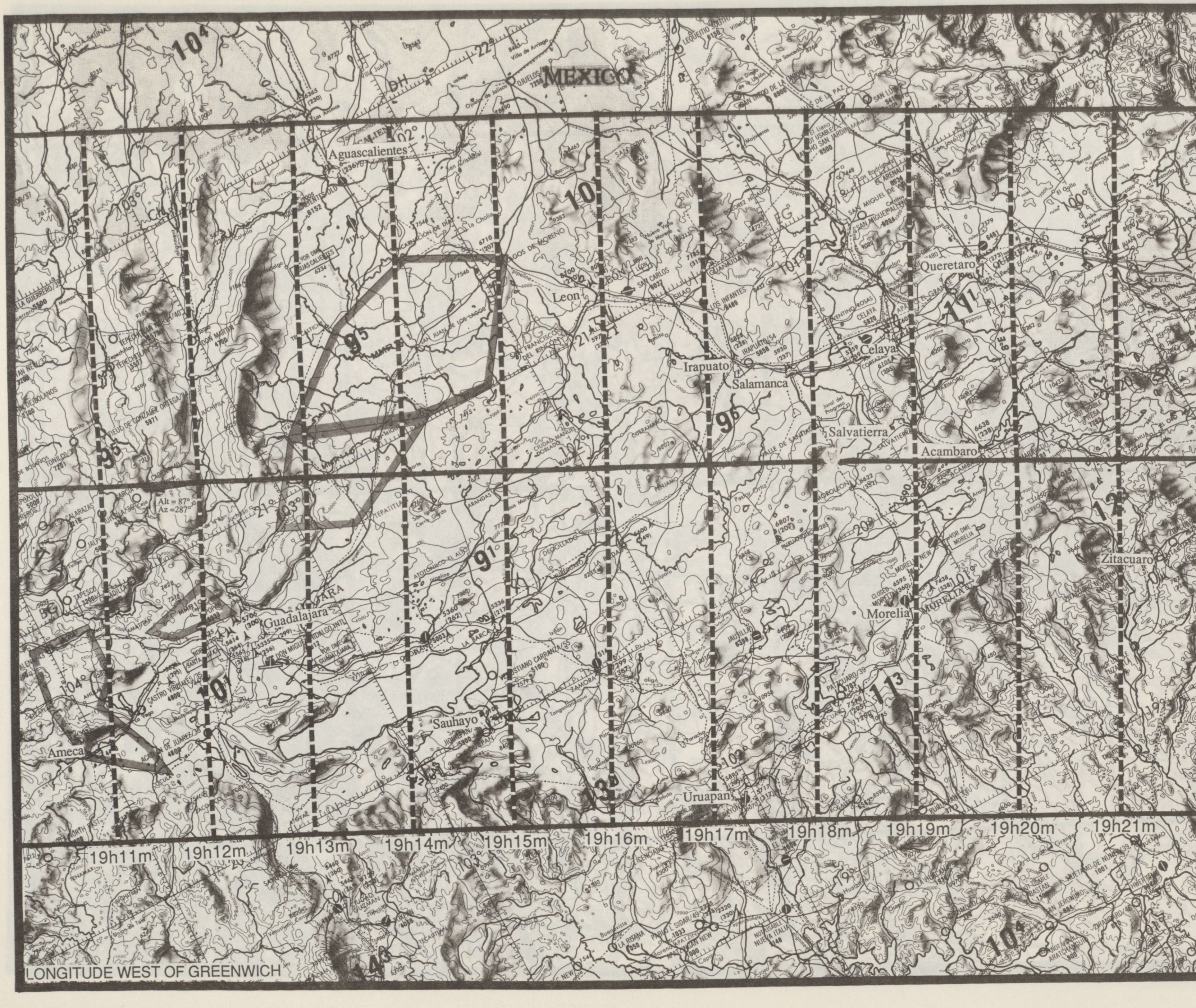
OPERATIONAL NAVIGATION CHART

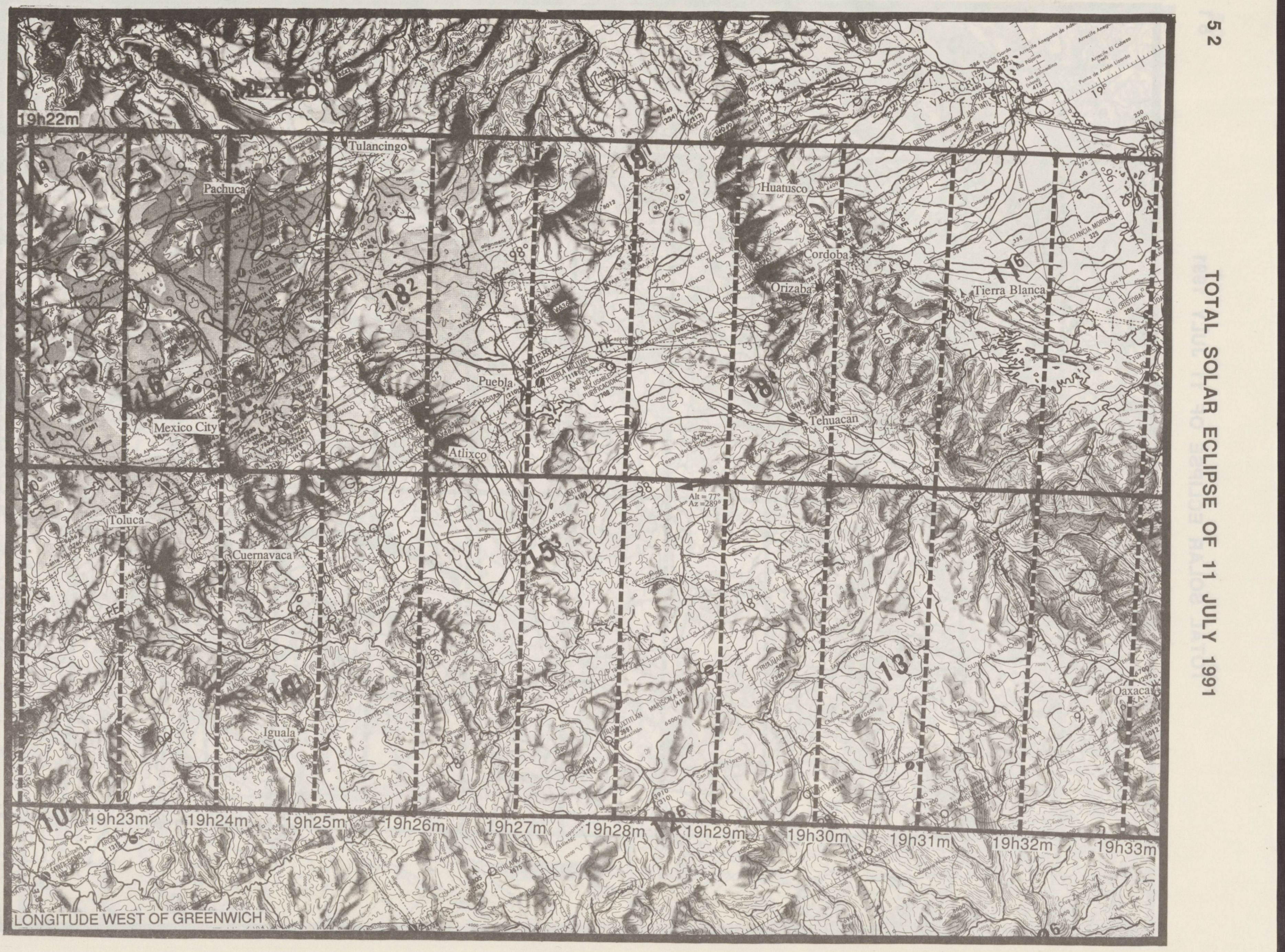
1:1,000,000

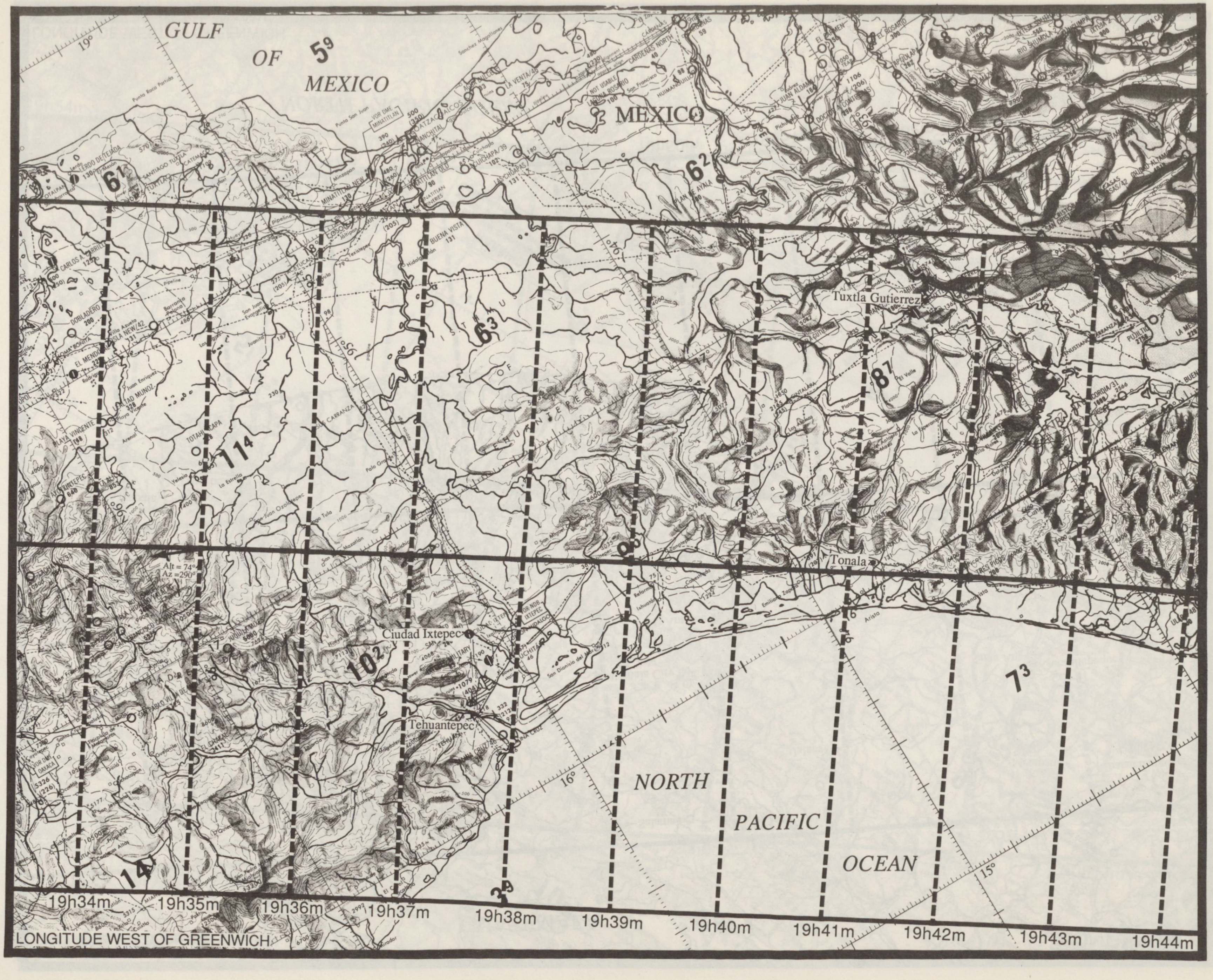

NORTH
PACIFIC
OCEAN
5³
5⁹
10⁴
1³
14¹
2¹
1⁴
HAWAIIAN ISLANDS
MOLOKAI
MAUI
LANAI
KAHOOLAWE
HAWAII
Lanai City
Lahaina
Wailuku
Kahului
Paia
Puunene
Hana
Kaupo
Makena
Ulupalakua
Keokea
Kalaupapa
Kamalo
Cape Halawa
Kauiki Head
Nukuele Point
Keoneoio
Honokohau
Nakalele Point
Olowalu
Kawaihae
Puako
Kiholo
Mahaiula
Keahole Point
Kailua Kona
Captain Cook
Kealakekua
Kealia
Honomu
Miloli
Kauna Point
Waiahukini
Ka Lae
Naalehu
Waiohinu
Pahala
Mountain View
Glenwood
Hilo
Honokaa
Kurtistown
Keaau
Leleiwi Point
Kaloli Point
Makuu
Pahoa
Cape Kumukahi
Kapoho
Upolu Point
Halaula
Mahukona
Mukapala
Hawi
MAUNA KEA
MAUNA LOA
KAALAKE
KAHUKU
PUU WAA WAA
WAIKOLOA
WAIMEA-KOHALA
PAAUHAN
WAIPUNALEI
PELEAU
PEPEEKEO
KALAUPAPA 26
KAANAPALI 10
UPOLU 96
HALAWA 560
VORTAC MAUI Chan 90
NDB VALLEY ISLAND
NDB MC GREGOR POINT
VOR DME KAMUELA Chan 80
UPOLU POINT Chan 70
VORTAC KONA Chan 104
VORTAC HILO Chan 116
NDB PAHOA
GENERAL LYMAN
R-3103
R-3101
W-195A
W-195B
Magnetic Disturbance of as much as 10° exists at ground level in this vicinity.
11°E
Alt = 20°
Az = 73°
21°
20°
19°
157°
156°
155°
17h31m30s
17h31m
17h30m30s
17h30m
17h29m30s
17h29m
AREA ... OUTER BOUNDARY
ADIZ OUTER BOU
ISLANDS
LONGITUDE WEST OF GREENWICH

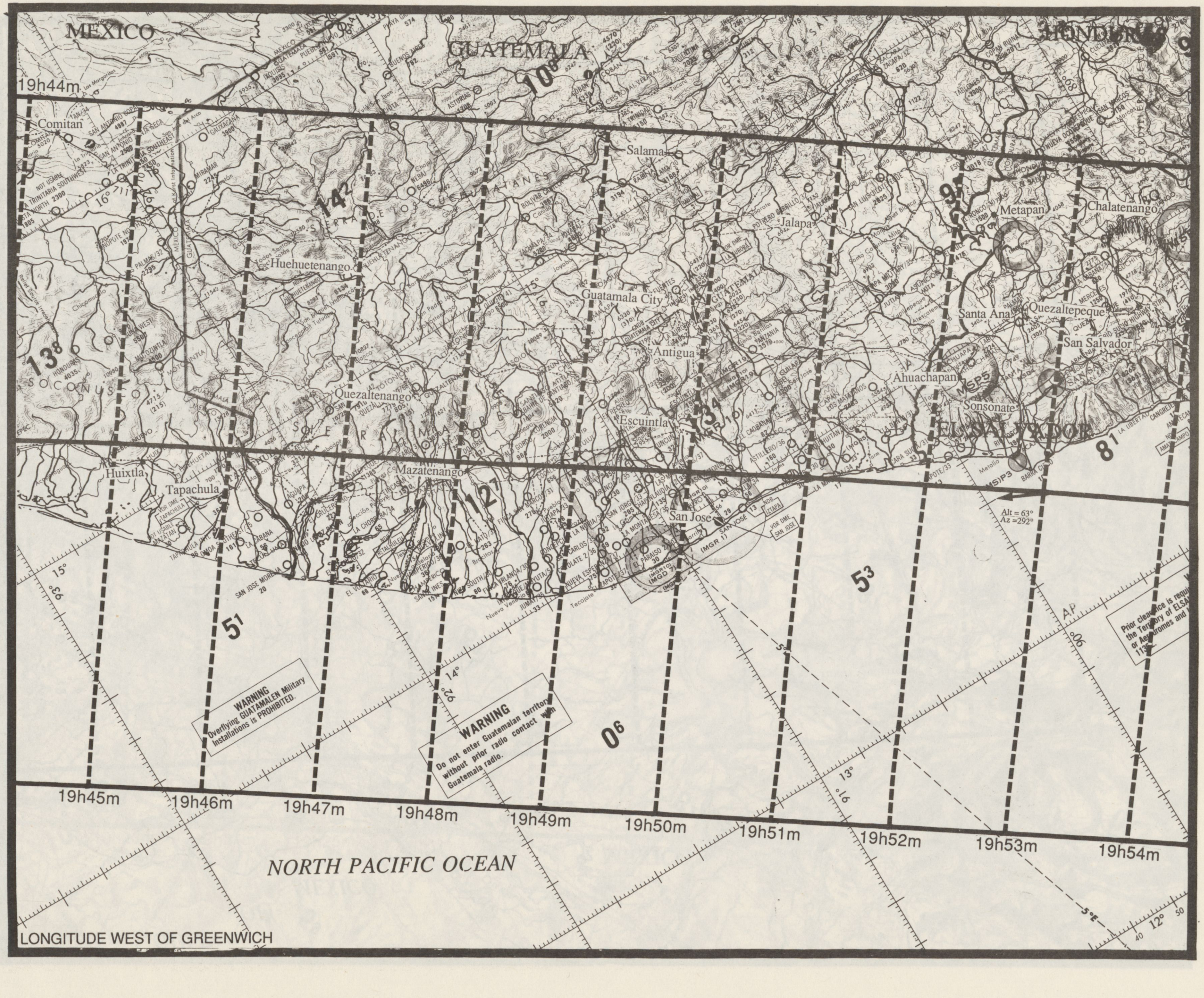

18h45m
18h46m
18h47m
18h48m
18h49m
18h50m
18h51m
18h52m
18h53m
18h54m
Baja California
MEXICO
GULF OF CALIFORNIA
NORTH PACIFIC OCEAN
Ejido Insurgentes
Villa Constitucion
Los Dolores
Santa Rita
Puerto Cortes
La Paz
San Pedro
Ensenada De Los Muertos
Los Inocentes
Todos Santos
Santiago
Cabo Pulmo
San Jose Del Cabo
San Lucas
Alt = 80°
Az = 99°
3²
2⁶
4⁵
8⁰
8⁰
112°
111°
110°
25°
24°
23°
LONGITUDE WEST OF GREENWICH

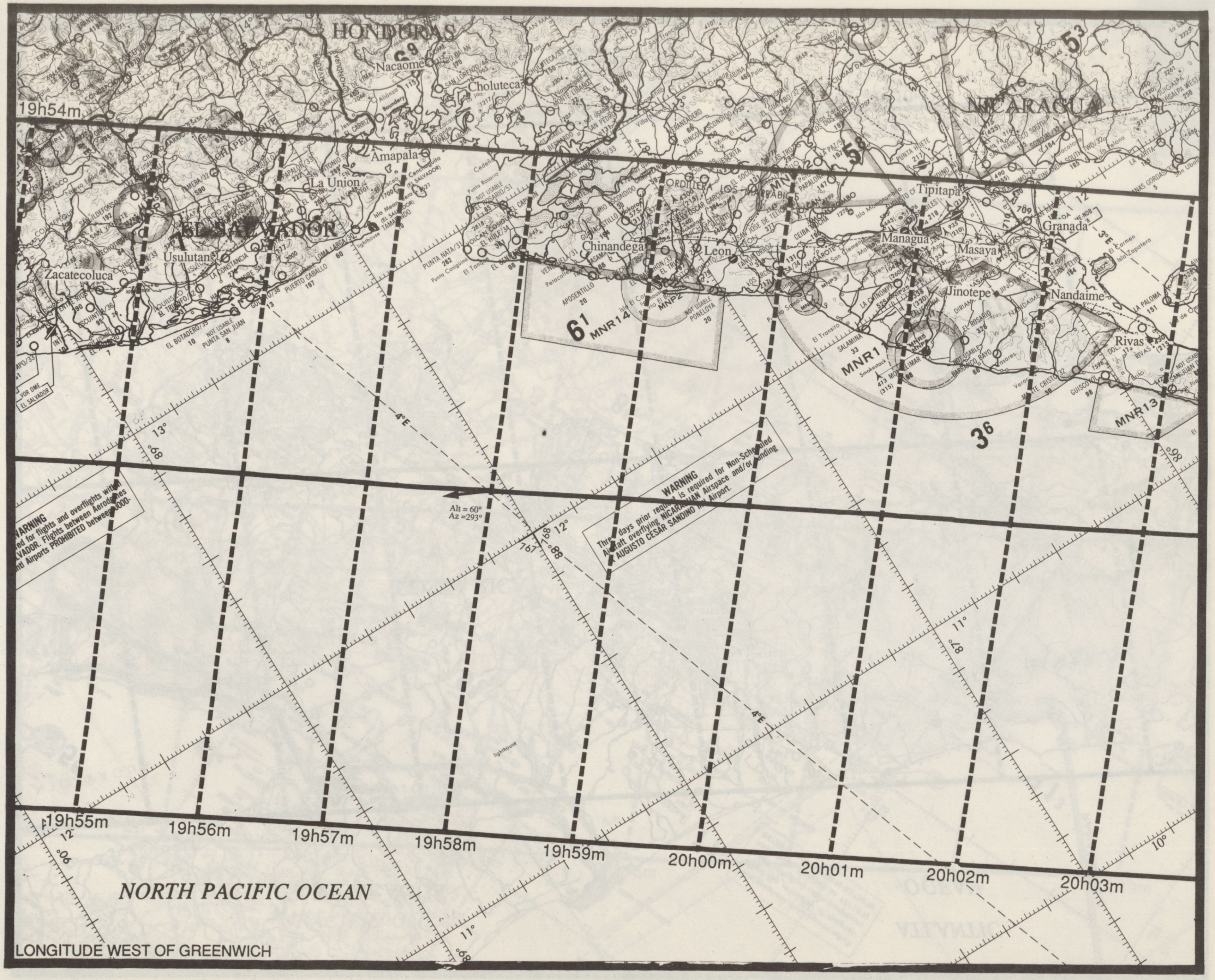

MEXICO
19h07m
19h08m
19h09m
19h10m
18h59m
19h00m
19h01m
19h02m
19h03m
19h04m
19h05m
19h06m
Alt = 88°
Az = 99°
Mazatlan
Tuxpan
Tepic
Puerto Vallarta
SIERRA MADRE OCCIDENTAL
ISLAS MARIAS
PACIFIC
OCEAN
24°
23°
22°
21°
20°
107°
106°
105°
104°
LONGITUDE WEST OF GREENWICH

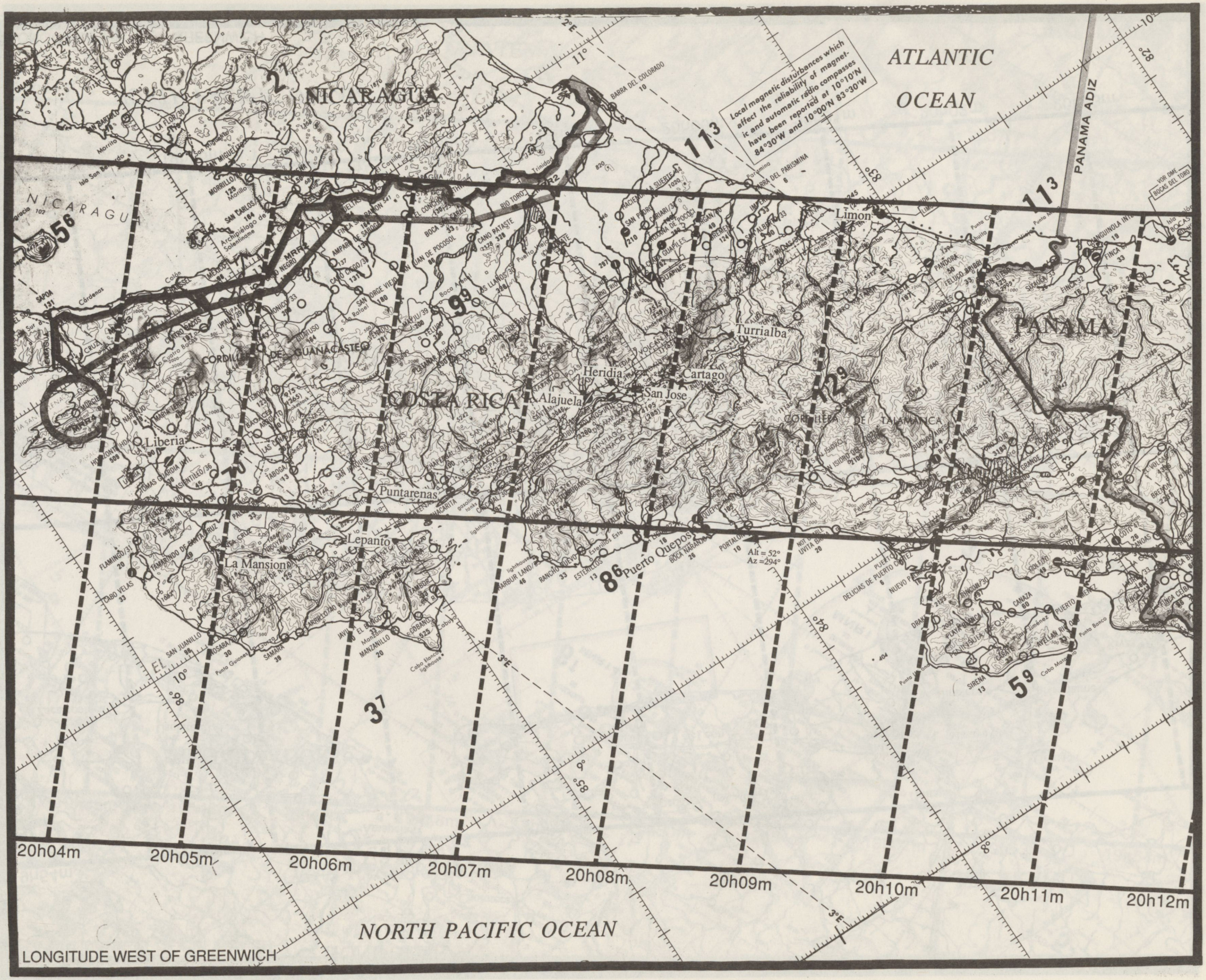

MEXICO
Aguascalientes
Leon
Queretaro
Irapuato
Salamanca
Celaya
Salvatierra
Acambaro
Alt = 87°
Az = 287°
Zitacuaro
Guadalajara
Morelia
Sauhayo
Ameca
Uruapan
19h11m
19h12m
19h13m
19h14m
19h15m
19h16m
19h17m
19h18m
19h19m
19h20m
19h21m
LONGITUDE WEST OF GREENWICH

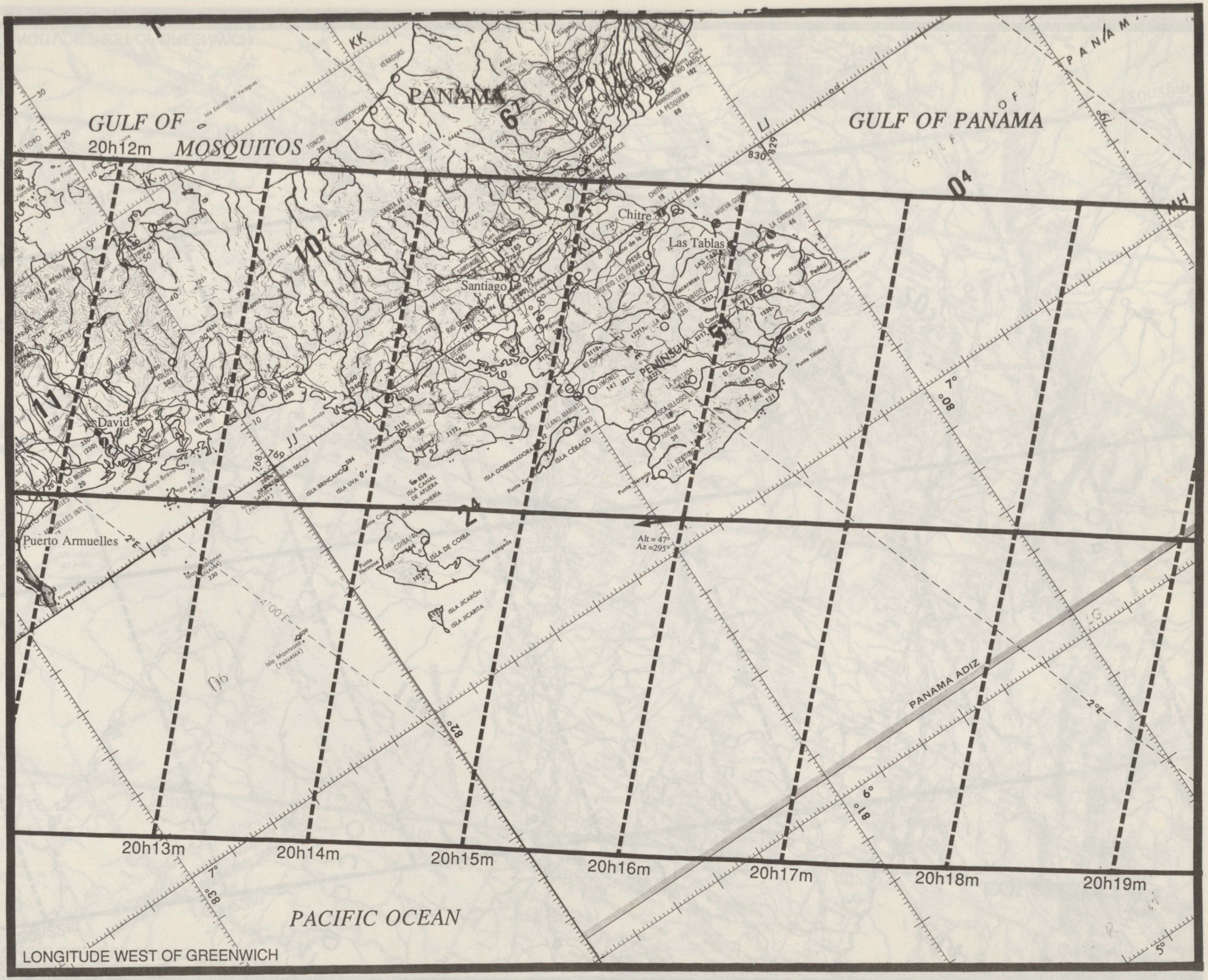

19h22m
MEXICO
VERACRUZ
Tulancingo
Pachuca
Huatusco
Cordoba
Orizaba
Tierra Blanca
Puebla
Mexico City
Atlixco
Tehuacan
Alt = 77°
Az = 289°
Toluca
Cuernavaca
Iguala
Oaxaca
19h23m
19h24m
19h25m
19h26m
19h27m
19h28m
19h29m
19h30m
19h31m
19h32m
19h33m
LONGITUDE WEST OF GREENWICH

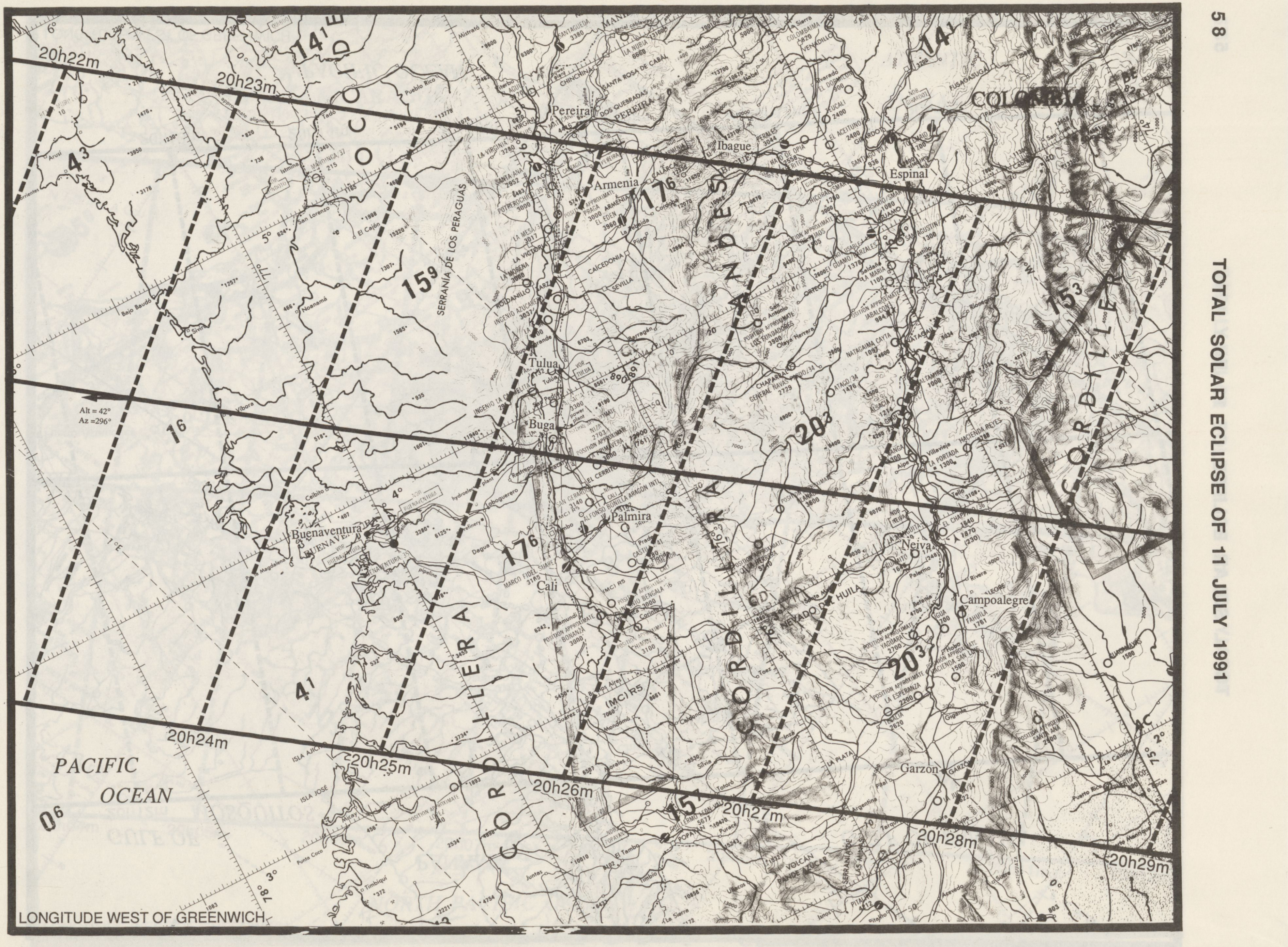

GULF OF MEXICO
MEXICO
Tuxtla Gutierrez
Tonala
Ciudad Ixtepec
Tehuantepec
Alt = 74°
Az = 290°
NORTH PACIFIC OCEAN
19°
16°
15°
19h34m
19h35m
19h36m
19h37m
19h38m
19h39m
19h40m
19h41m
19h42m
19h43m
19h44m
LONGITUDE WEST OF GREENWICH

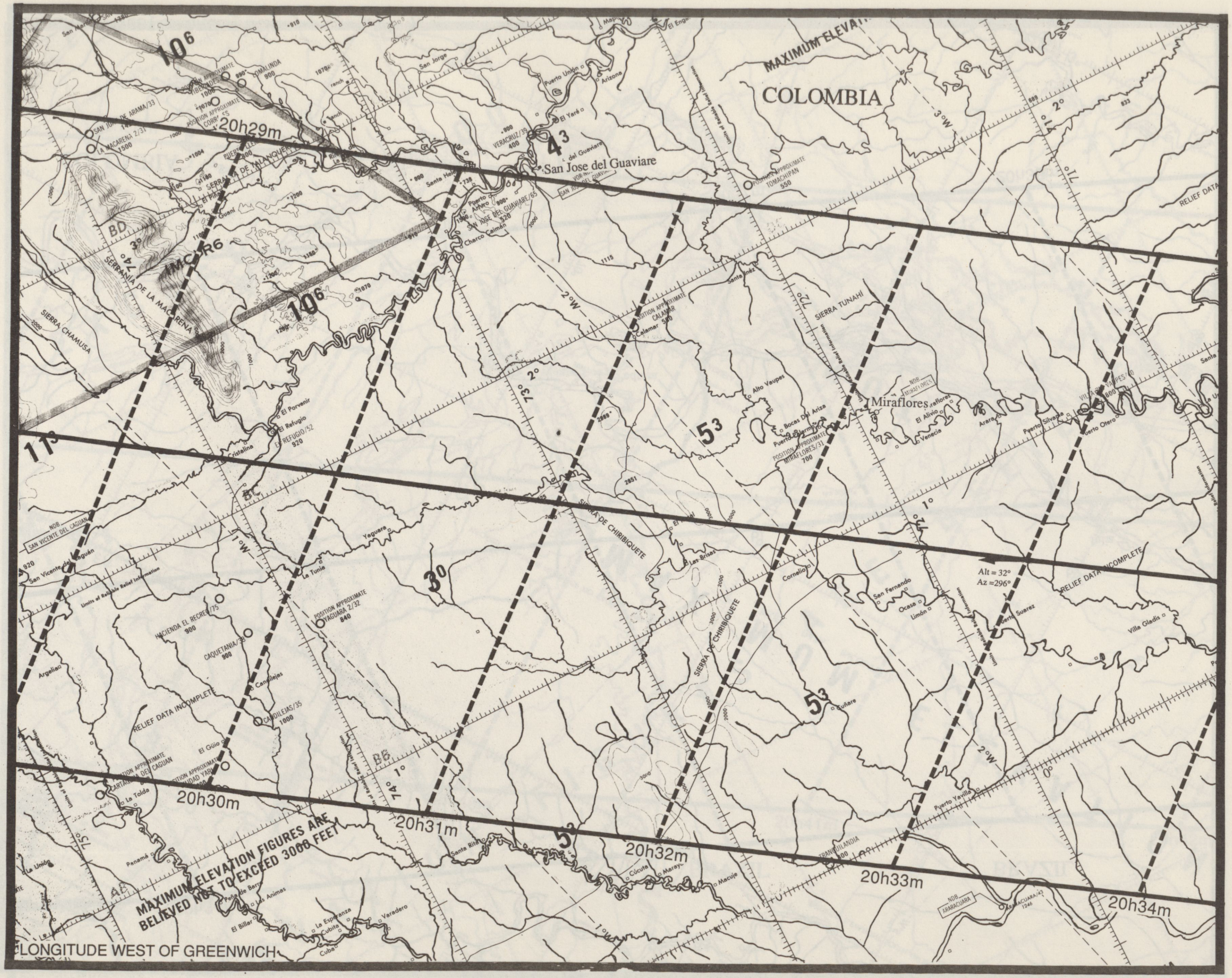

MEXICO
GUATEMALA
HONDURAS
EL SALVADOR
NORTH PACIFIC OCEAN
19h44m
19h45m
19h46m
19h47m
19h48m
19h49m
19h50m
19h51m
19h52m
19h53m
19h54m
Comitan
Huehuetenango
Quezaltenango
Mazatenango
Huixtla
Tapachula
Salama
Guatamala City
Antigua
Escuintla
San Jose
Jalapa
Metapan
Chalatenango
Santa Ana
Quezaltepeque
San Salvador
Ahuachapan
Sonsonate
Alt = 63°
Az = 292°
WARNING
Overflying GUATEMALEN Military Installations is PROHIBITED.
WARNING
Do not enter Guatemalan territory without prior radio contact with Guatemala radio.
LONGITUDE WEST OF GREENWICH

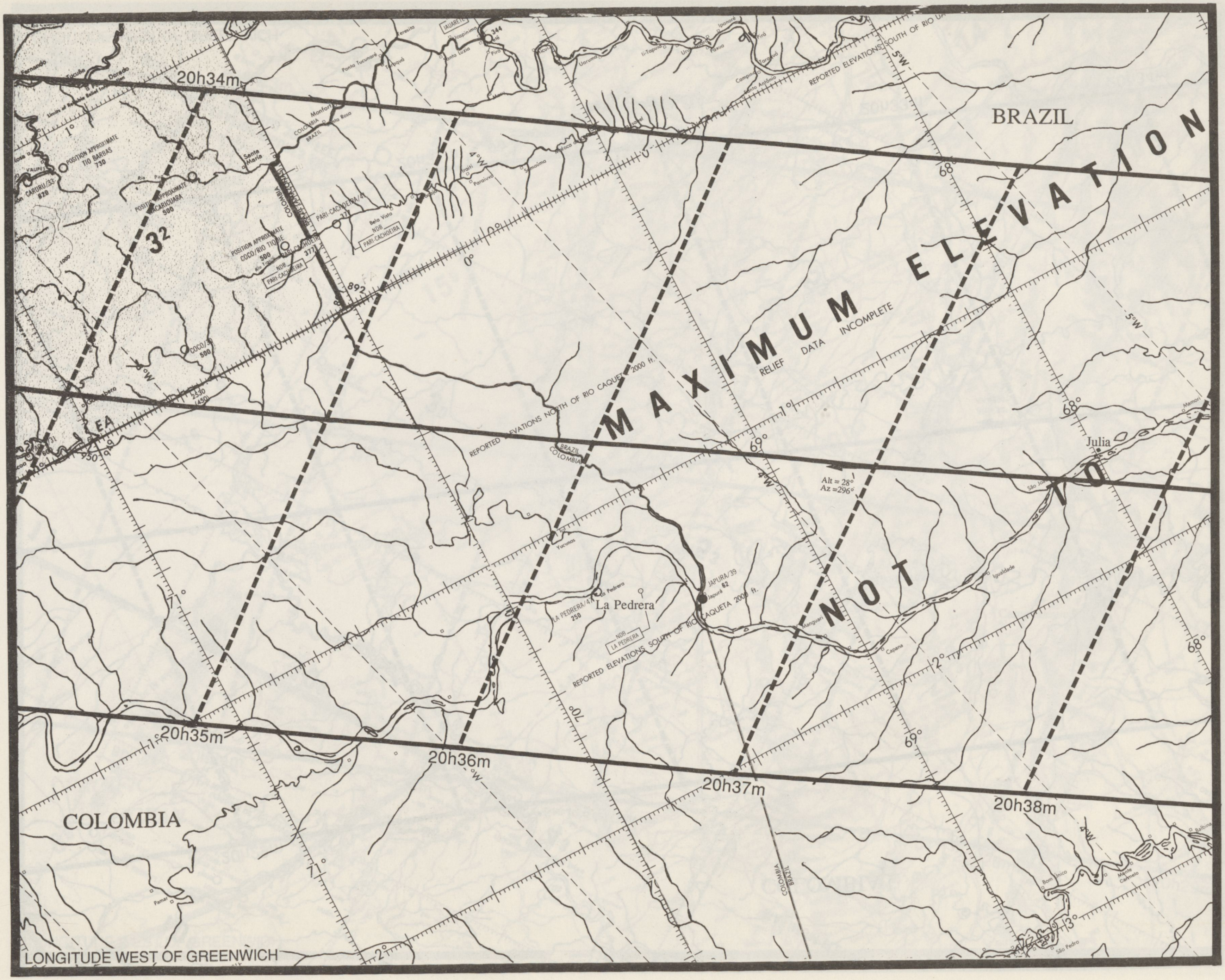

HONDURAS
Nacaome
Choluteca
NICARAGUA
19h54m
Amapala
La Union
EL SALVADOR
Usulutan
Zacatecoluca
Chinandega
Leon
Tipitapa
Managua
Masaya
Granada
Jinotepe
Nandaime
Rivas
MNR14
MNR1
MNR13
13°
12°
11°
10°
89°
88°
87°
86°
90°
4°E
3°E
Alt = 60°
Az = 293°
WARNING
Three days prior request is required for Non-Scheduled Aircraft overflying NICARAGUAN Airspace and/or landing at AUGUSTO CESAR SANDINO Intl Airport.
WARNING
Required for flights and overflights within EL SALVADOR. Flights between Aerodromes and Intl Airports PROHIBITED between 2000-
19h55m
19h56m
19h57m
19h58m
19h59m
20h00m
20h01m
20h02m
20h03m
NORTH PACIFIC OCEAN
LONGITUDE WEST OF GREENWICH

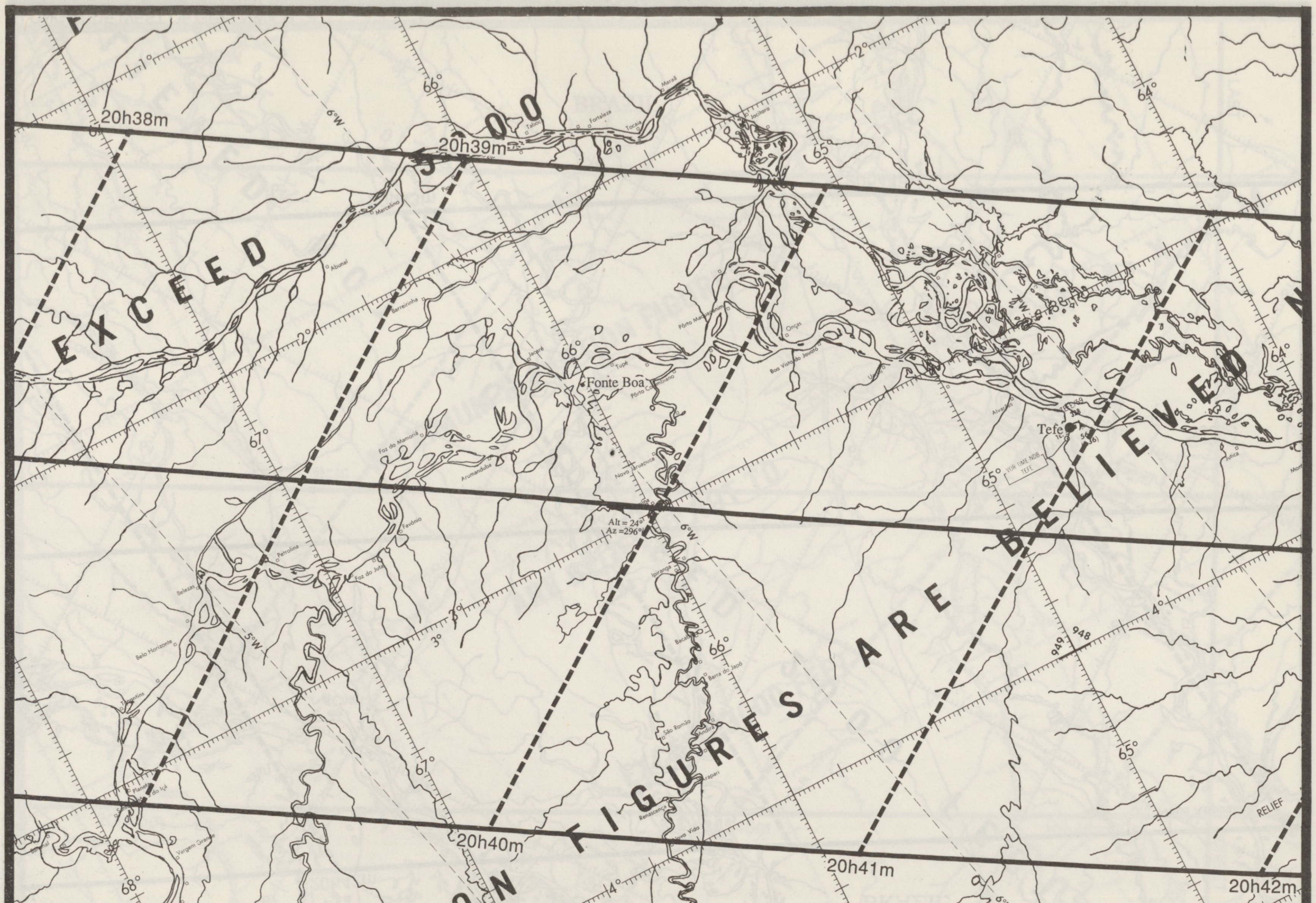

ATLANTIC OCEAN
NICARAGUA
COSTA RICA
PANAMA
PANAMA ADIZ
Local magnetic disturbances which affect the reliability of magnetic and automatic radio compasses have been reported at 10°10'N 84°30'W and 10°00'N 83°30'W
Limon
Turrialba
Cartago
San Jose
Heridia
Alajuela
Liberia
Puntarenas
Lepanto
La Mansion
Puerto Quepos
CORDILLERA DE GUANACASTE
CORDILLERA DE TALAMANCA
Alt = 52°
Az = 294°
2^7
5^6
7^0
9^9
11^3
11^3
12^9
8^6
3^7
5^9
11°
10°
9°
8°
82°
83°
84°
85°
86°
2°E
3°E
3°E
20h04m
20h05m
20h06m
20h07m
20h08m
20h09m
20h10m
20h11m
20h12m
NORTH PACIFIC OCEAN
LONGITUDE WEST OF GREENWICH

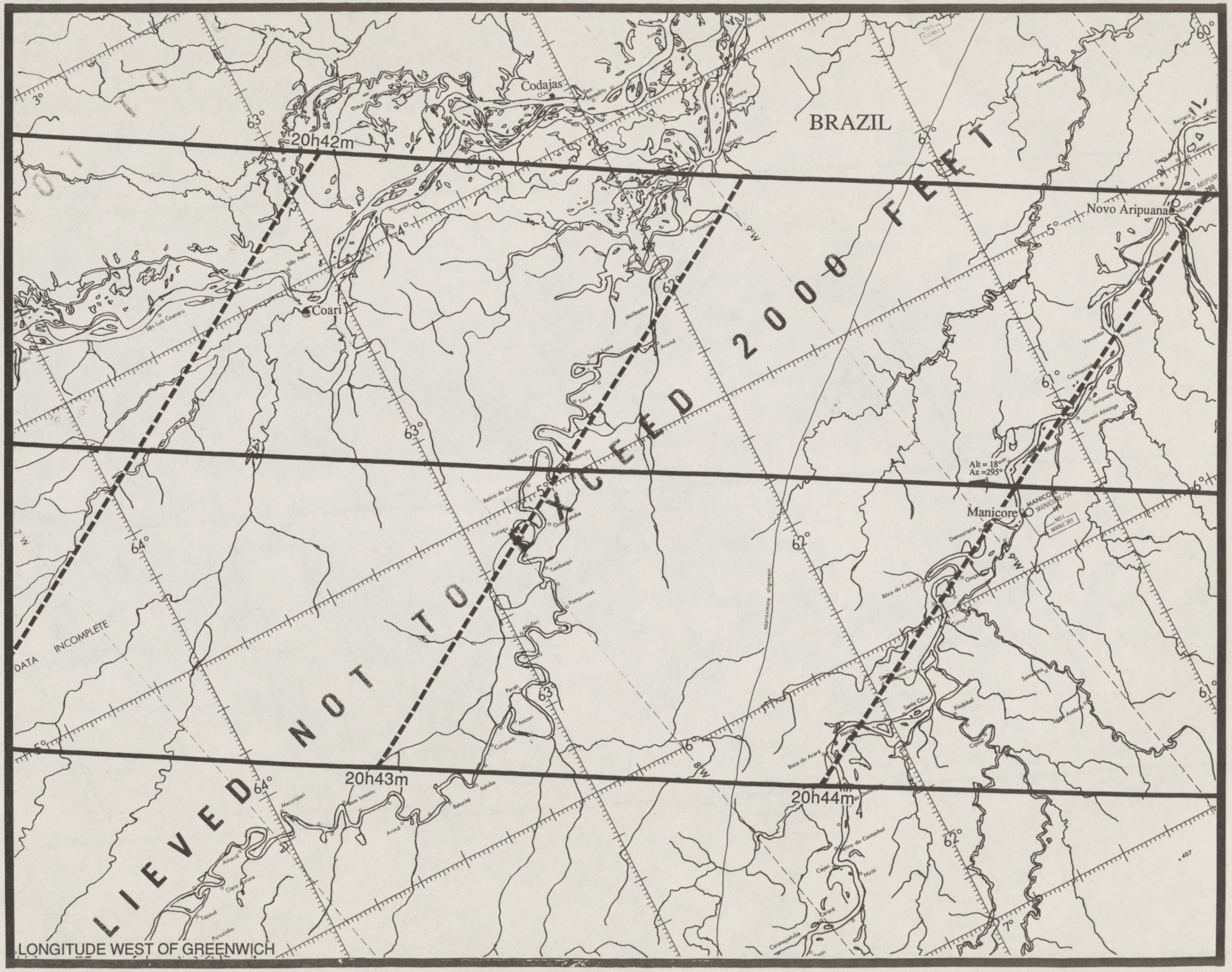

PANAMA
GULF OF MOSQUITOS
GULF OF PANAMA
PACIFIC OCEAN
20h12m
20h13m
20h14m
20h15m
20h16m
20h17m
20h18m
20h19m
Chitre
Las Tablas
Santiago
David
Puerto Armuelles
PENINSULA AZUERO
ISLA DE COIBA
ISLA JICARÓN
ISLA JICARITA
ISLA CEBACO
ISLA GOBERNADORA
ISLA BRINCANCO
ISLA UVA
ISLA CANAL DE AFUERA
Isla Montuoso (PANAMA)
Alt = 47°
Az = 295°
PANAMA ADIZ
2°E
7°
80°
81°
82°
83°
6°
KK
JJ
LJ
NH
LONGITUDE WEST OF GREENWICH

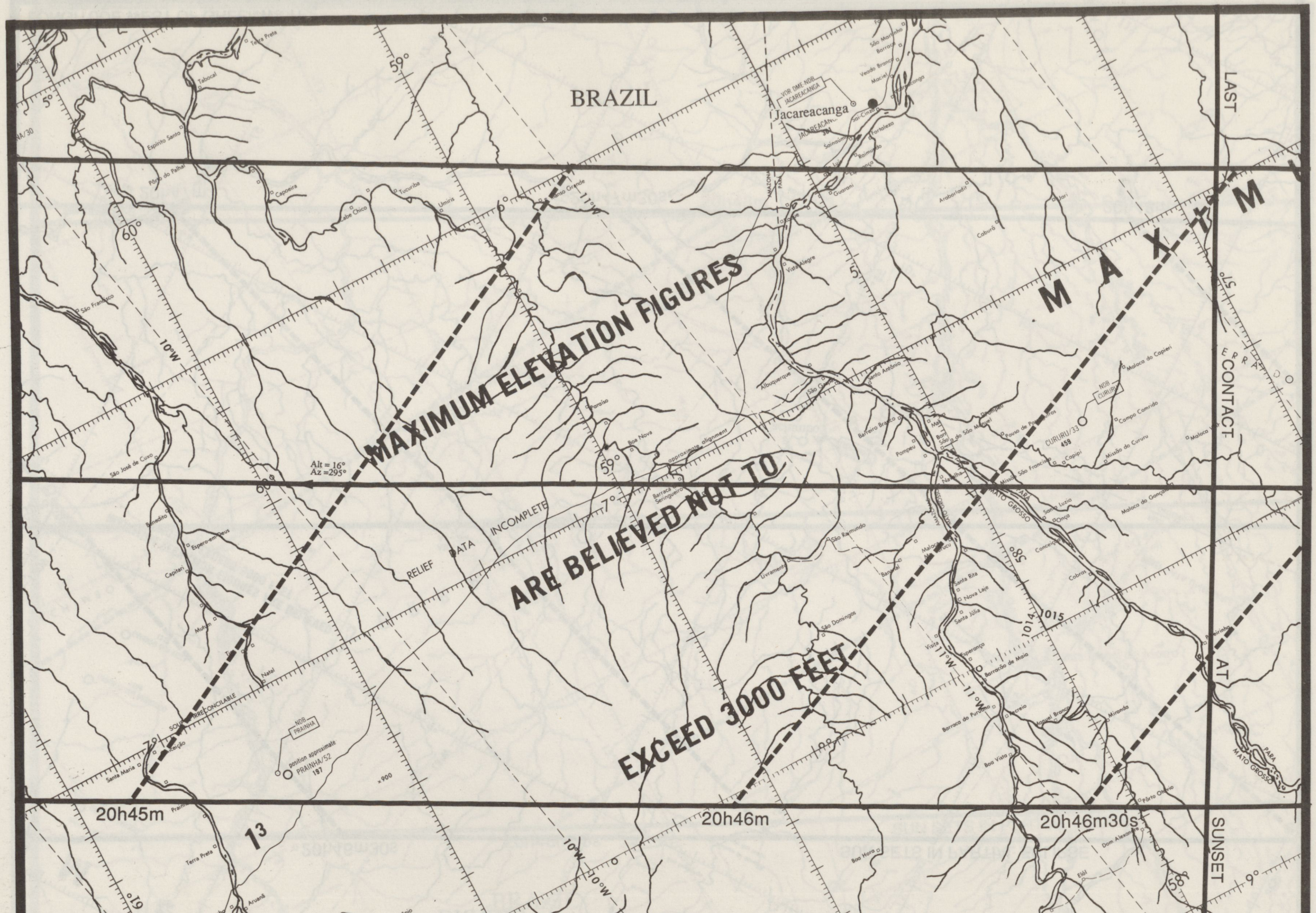

20h22m
20h23m
20h24m
20h25m
20h26m
20h27m
20h28m
20h29m
4³
1⁶
4¹
0⁶
14¹
15⁹
17⁶
17⁶
20³
20³
15³
15¹
14¹
Alt = 42°
Az = 296°
PACIFIC
OCEAN
COLOMBIA
CORDILLERA OCCIDENTAL
CORDILLERA DE LOS ANDES
CORDILLERA CENTRAL
CORDILLERA
SERRANÍA DE LOS PERAGUAS
Pereira
Armenia
Ibague
Espinal
Tulua
Buga
Palmira
Cali
Buenaventura
Neiva
Campoalegre
Garzon
NEVADO DEL HUILA
VOLCAN PAN DE AZUCAR
5°
4°
3°
2°
77°
78°
75°
LONGITUDE WEST OF GREENWICH

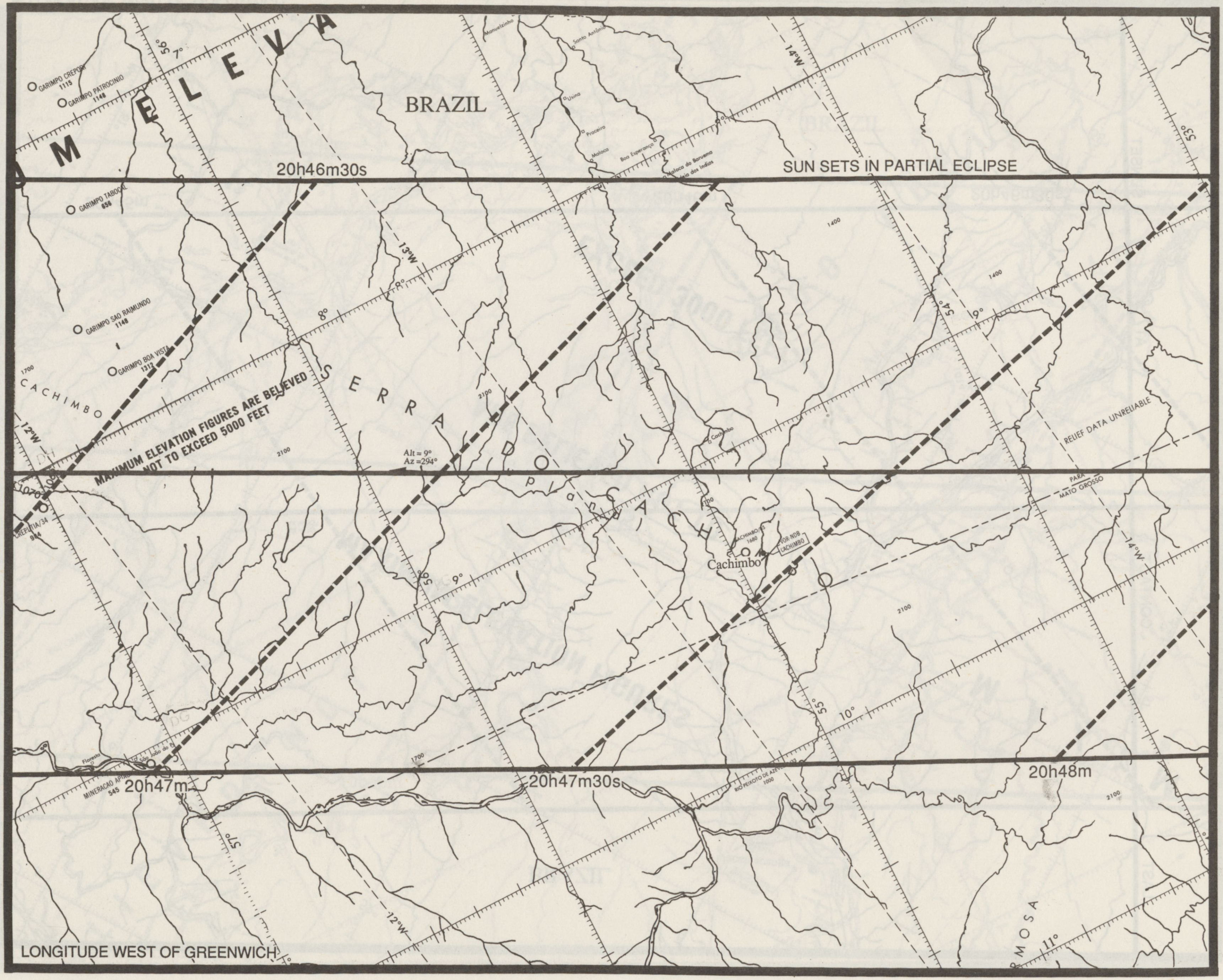

COLOMBIA
MAXIMUM ELEVATION
San Jose del Guaviare
Miraflores
20h29m
20h30m
20h31m
20h32m
20h33m
20h34m
10⁶
4³
5³
3⁰
11°
1°
2°
3°
73° 2°
72°
74° 1°
75°
71°
1°W
2°W
3°W
Alt = 32°
Az = 296°
RELIEF DATA INCOMPLETE
SIERRA DE CHIRIBIQUETE
SIERRA TUNAHI
SERRANIA DE LA MACARENA
SIERRA CHAMUSA
SERRANIA DE MALANQUE
Calamar
Alto Vaupes
La Tunia
Yaguara
San Vicente del Caguán
El Porvenir
El Refugio
Cristalina
Puerto Silvania
Puerto Suarez
Villa Gladis
San Fernando
Puerto Yavilla
Tranquilandia
Santa Rita
Cucuta
Peñas de Berri
Las Animas
El Billar
La Esperanza
Cubita
Varadero
Cuba
Argelino
La Tolda
Candilejas
El Guio
Puerto Arturo
Charco Caiman
MAXIMUM ELEVATION FIGURES ARE BELIEVED NOT TO EXCEED 3000 FEET
LONGITUDE WEST OF GREENWICH

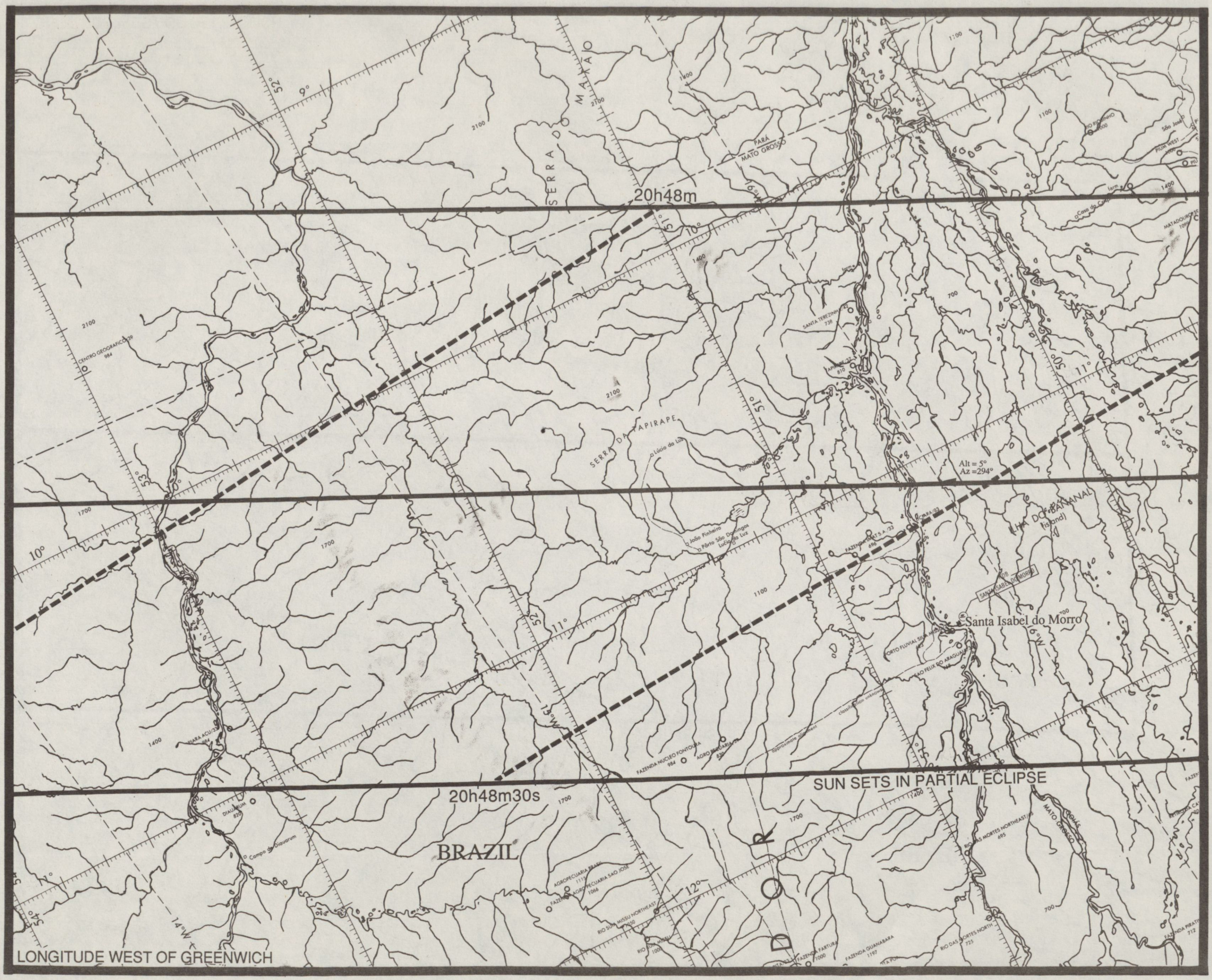

20h34m
20h35m
20h36m
20h37m
20h38m
BRAZIL
COLOMBIA
MAXIMUM ELEVATION
NOT TO
RELIEF DATA INCOMPLETE
La Pedrera
Julia
Alt = 28°
Az = 296°
REPORTED ELEVATIONS NORTH OF RIO CAQUETA 2000 ft.
REPORTED ELEVATIONS SOUTH OF RIO CAQUETA 2000 ft.
REPORTED ELEVATIONS SOUTH OF RIO UAUPES
JAPURA/39
LA PEDRERA
PARI-CACHOEIRA
32
892
0°
1°
2°
3°
68°
69°
70°
71°
4°W
5°W
LONGITUDE WEST OF GREENWICH

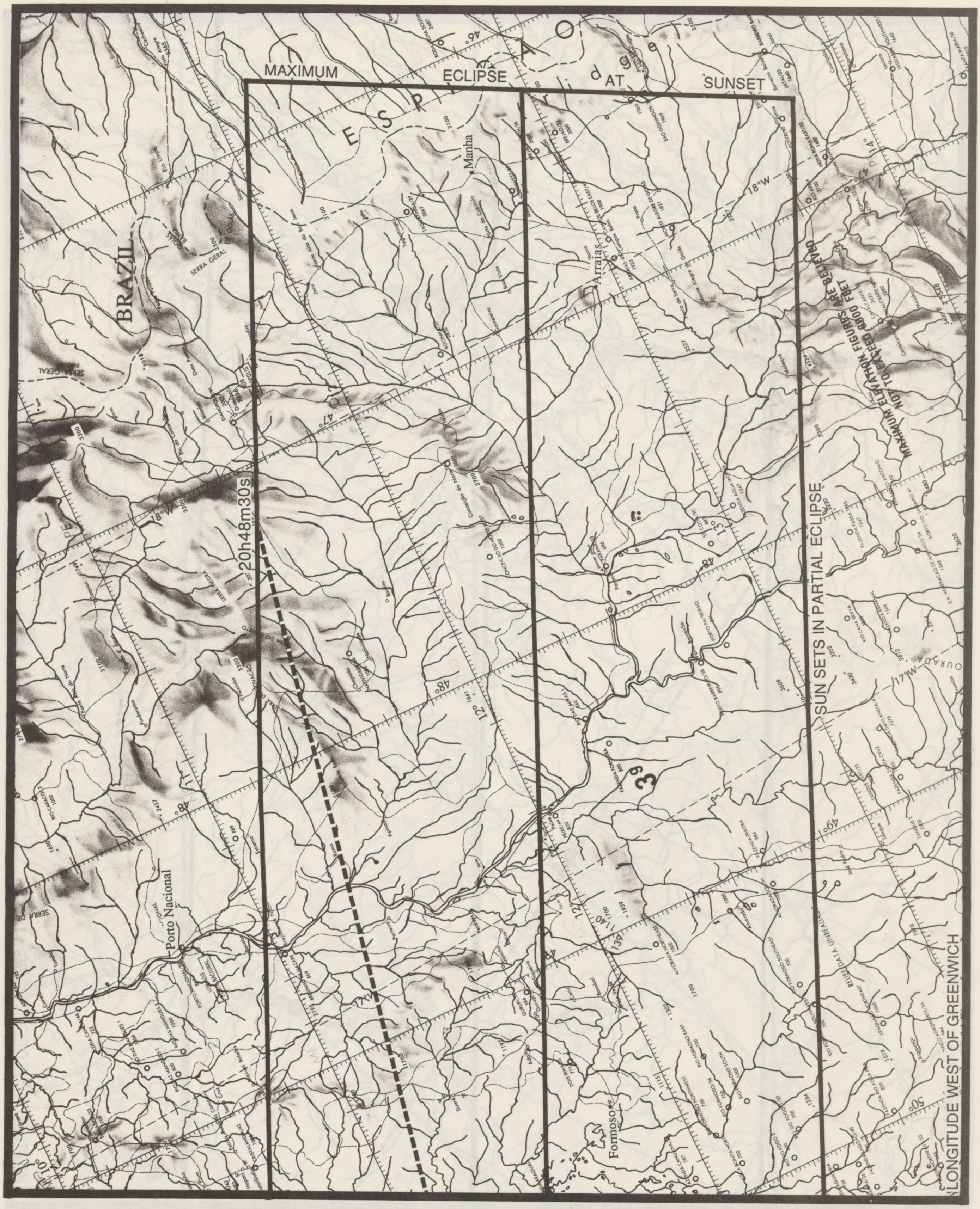

20h38m
20h39m
20h40m
20h41m
20h42m
EXCEED 5000
EVATION FIGURES ARE BELIEVED
Fonte Boa
Tefe
Alt = 24°
Az = 296°
BRAZIL
1°
2°
3°
4°
5°
64°
65°
66°
67°
68°
6°W
5°W
948
949
RELIEF
LONGITUDE WEST OF GREENWICH


20h42m
20h43m
20h44m
BRAZIL
Codajas
Coari
Novo Aripuanã
Manicore
Alt = 18°
Az = 295°
LIEVED NOT TO EXCEED 2000 FEET
NOT TO
DATA INCOMPLETE
approximate alignment
3°
4°
5°
6°
7°
60°
61°
62°
63°
64°
LONGITUDE WEST OF GREENWICH


BRAZIL
Jacareacanga
MAXIMUM ELEVATION FIGURES
ARE BELIEVED NOT TO
EXCEED 3000 FEET
MAXIM
LAST
CONTACT
AT
SUNSET
20h45m
20h46m
20h46m30s
Alt = 16°
Az = 295°
RELIEF DATA INCOMPLETE
approximate alignment
position approximate
PRAINHA/52
197
CURURU/33
459
NDB CURURU
NDB PRAINHA
MATO GROSSO
PARA
59°
60°
58°
5°
7°
8°
9°
10°W
11°W
1014
1015
1³
LONGITUDE WEST OF GREENWICH


MAXIMUM ELEVATION FIGURES ARE BELIEVED NOT TO EXCEED 5000 FEET
BRAZIL
SUN SETS IN PARTIAL ECLIPSE
20h46m30s
20h47m
20h47m30s
20h48m
SERRA DO CACHIMBO
CACHIMBO
Cachimbo
RELIEF DATA UNRELIABLE
PARA
MATO GROSSO
GARIMPO CREPORI 1115
GARIMPO PATROCINIO 1148
GARIMPO TABOCAL 656
GARIMPO SAO RAIMUNDO 1148
GARIMPO BOA VISTA 1312
Alt = 9°
Az = 294°
12°W
13°W
14°W
56°
55°
54°
53°
51°
7°
8°
9°
10°
11°
1400
1700
2100
LONGITUDE WEST OF GREENWICH


20h48m
20h48m30s
SUN SETS IN PARTIAL ECLIPSE
Alt = 5°
Az = 294°
Santa Isabel do Morro
ILHA DO BANANAL
(island)
SERRA DA TAPIRAPE
PARÁ
MATO GROSSO
BRAZIL
LONGITUDE WEST OF GREENWICH
9°
10°
11°
12°
50°
51°
52°
53°
54°


MAXIMUM ECLIPSE AT SUNSET
ESPIGÃO
BRAZIL
SERRA GERAL DE GOIÁS
Manha
Arraias
20h48m30s
18°W
17°W
SUN SETS IN PARTIAL ECLIPSE
MAXIMUM ELEVATION FIGURES ARE BELIEVED NOT TO EXCEED 6000 FEET
Porto Nacional
Formoso
12°
13°
14°
11°
10°
47°
48°
49°
50°
RELIEF DATA UNRELIABLE
LONGITUDE WEST OF GREENWICH